

**HOW CAN THE MARINE CORPS BEST EMPLOY THE F/A-18D AS AN
AIRBORNE SUPPORTING ARMS COORDINATION PLATFORM
IN SUPPORT OF THE MARINE AIR GROUND TASK FORCE?**

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degree

MASTER OF MILITARY ART AND SCIENCE

by

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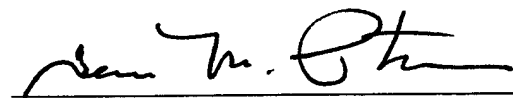
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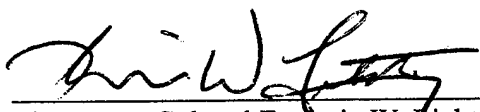
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ABSTRACT

HOW CAN THE MARINE CORPS BEST EMPLOY THE F/A-18D AS AN AIRBORNE SUPPORTING ARMS COORDINATION PLATFORM IN SUPPORT OF THE MARINE AIR GROUND TASK FORCE?, by Major Mark Vincent Dillard, USMC, 186 pages.

The future of the Marine Corps resounds in *Operational Maneuver from the Sea*. This doctrine demands complete mastery of the littoral battle space to project amphibious combat power farther and faster than ever before. Critical to the success of any military operation is the commander's ability to quickly make accurate tactical decisions. Because he cannot be physically present over the entire battlefield, he must have systems in place to give him the broad tactical perspective that he lacks. The F/A-18D provides the MAGTF commander with an unparalleled bird's eye view of the battle space, and the ability to reach out to any echelon of his forces instantly. Perhaps more importantly, the F/A-18D offers the commander informational dominance over the enemy in time and space, and the ability to bring combat power to bear on high payoff targets at the critical moment to achieve decisive tactical victory. This thesis addresses the inefficient employment of the F/A-18D as an airborne supporting arms coordinator or SAC(A). The introduction of the F/A-18D to the Fleet was not accompanied by carefully considered doctrine to match SAC(A) mission tasking with the aircraft's capabilities. The recommendations contained herein seek to correct the problems that have resulted.

TABLE OF CONTENTS

	Page
APPROVAL PAGE	ii
ABSTRACT	iii
LIST OF ABBREVIATIONS	v
LIST OF ILLUSTRATIONS	ix
 CHAPTER	
1. INTRODUCTION	1
2. REVIEW OF LITERATURE	10
3. RESEARCH METHODOLOGY	15
4. ANALYSIS	21
5. CONCLUSIONS AND RECOMMENDATIONS	90
 APPENDIX	
A. TECHNIQUES, TACTICS, AND PROCEDURES FOR SAC(A)	125
B. ADVANCED TACTICAL AIRBORNE RECONNAISSANCE SET	171
C. STABLIZED BINOCULARS INFORMATION	176
D. FUEL CALCULATIONS	180
BIBLIOGRAPHY	184
INITIAL DISTRIBUTION LIST	186

ABBREVIATIONS

AAA	Anti Aircraft Artillery
ABCCC	Airborne Command Control Communications
ACA	Airspace Coordination Area
ACE	Aviation Combat Element
ACI	Amplifier Control Intercommunication
ADF	Automatic Direction Finder
AFARN	Air Force Air Request Net
AGL	Above Ground Level
ANGLICO	Air Naval Gunfire Liaison Company
APU	Auxiliary Power Unit
ASAP	As Soon As Possible
ATARS	Advanced Tactical Airborne Reconnaissance Set
BDA	Battle Damage Assessment
BHA	Bomb Hit Assessment
BLT	Battalion Landing Team
CAS	Close Air Support
CAX	Combined Arms Exercise
CMS	Cockpit Management System
CP	Command Post
DASC	Direct Air Support Center
DVO	Direct View Optics
FAC	Forward Air Controller
FAC(A)	Forward Air Controller (Airborne)

FARP	Forward Arming Refueling Point
FEBA	Forward Edge of the Battle Area
FLOT	Forward Line Of Troops
FM	Frequency Modulated
FOR	Field Of Regard
FOV	Field Of View
FSCC	Fire Support Coordination Center
FSCL	Fire Support Coordination Line
GCE	Ground Combat Element
GMT	Greenwich Mean Time
GPS	Global Positioning System
HAFU	Hostile Ambiguous Friendly Unknown
HARM	High-speed Anti Radiation Missile
HF	High Frequency
HMLA	Helicopter Marine Light Attack
HSI	Horizontal Situation Indicator
HSS	Helmet Sight Sub-system
HUD	Head Up Display
IADS	Integrated Air Defense System
INS	Inertial Navigation System
IP	Initial Point
IRLS	Infrared Line Scanner
JFACC	Joint Forces Air Component Commander
JOG	Joint Operations Ground
JTAR	Joint Tactical Airstrike Request

LAEO	Low Altitude Electro Optical
LDT	Laser Detector Tracker
LST	Laser Spot Tracker
LTD/R	Laser Target Designator / Ranger
MACCS	Marine Air Command and Control System
MAEO	Medium Altitude Electro Optical
MAGTF	Marine Air Ground Task Force
MAN PADS	Man Portable Air Defense Systems
MAWTS	Marine Aviation Weapons and Tactics Squadron
MCAS	Marine Corps Air Station
MEF	Marine Expeditionary Force
MFD	Multi Function Display
MIDS	Multifunctional Information Distribution System
MME	Manually Modified Entry
MNT	Manual New Threat
MSL	Mean Sea Level
NAVFLIR	Navigation Forward Looking Infrared
NSFS	Naval Surface Fire Support
NSN	National Stock Number
NTS	Night Target System
NVG	Night Vision Goggles
ORT	Optical Relay Tube
OMFTS	Operational Maneuver From The Sea
RLT	Regimental Landing Team
RWR	Radar Warning Team

SA	Situational Awareness
SAC(A)	Supporting Arms Coordination (Airborne)
SAM	Surface to Air Missile
SAR	Search And Rescue
SCAR	Strike Coordination And Reconnaissance
SINCGARS	Single Channel Air Ground Radio System
STOM	Ship To Objective Maneuver
TAC(A)	Tactical Air Coordinator (Airborne)
TACAN	Tactical Air Navigation
TACC	Tactical Air Command Center
TACP	Tactical Air Control Party
TACP(L)	Tactical Air Control Party (Local)
TAD	Tactical Air Direction
TAOC	Tactical Air Operations Center
TAR/HR Net	Tactical Air Request / Helicopter Request Net
TAS	True Air Speed
TATC Net	Tactical Air Traffic Control Net
TFLIR	Targeting Forward Looking Infrared
TOT	Time On Target
UHF	Ultra High Frequency
VHF	Very High Frequency
VOX	Voice Operated Transmit
VR/TAC(A)	Visual Reconnaissance / TAC(A)
WSO	Weapon Systems Officer
WYPT	Waypoint

ILLUSTRATIONS

Figure	Page
1. T-6 Mosquito	44
2. OV-10 Bronco.....	51
3. OA-10A Thunderbolt II.....	62
4. AH-1W Super Cobra.....	70
5. F/A-18D Hornet.....	78
6. CAS Stack Plan.....	102
7. FAC(A) Employment.....	106
8. TAC(A) Employment	112
9. SCAR Employment	118

Table	Page
1. T-6 Specifications.....	45
2. OV-10 Specifications.....	52
3. OA-10A Specifications	63
4. AH-1W Specifications	71
5. F/A-18D Specifications.....	79

CHAPTER 1

INTRODUCTION

Background

The two-seat F/A-18D Hornet entered service with the Marine Corps in October of 1989. It was designed as a multirole aircraft to replace three aging aircraft in the Marine Corps inventory, which had served since the Vietnam era. In the role of all-weather day and night attack, the F/A-18D replaced the venerable A-6E Intruder. Equipped with the Advanced Tactical Airborne Reconnaissance System (ATARS) it replaced the RF-4B Phantom in the role of tactical reconnaissance, and it replaced the OA-4M Sky Hawk in the role of fast forward air controller. After Desert Storm, the Marine Corps retired the OV-10 Bronco, which had served as the Corps' primary airborne supporting arms control platform since 1968. The F/A-18D was tasked, along with the Marine light attack helicopter community, to pick up the OV-10 Bronco's missions.

The decision to buy the F/A-18D was monumental because it replaced four obsolete aircraft. The F/A-18D shares 95 percent commonality with the Marine Corps' single-seat strike fighter, the F/A-18C. This reduced the number of tactical fixed wing aircraft types in the Marine Air Wing from seven to three: the F/A-18 Hornet series, the AV-8B Harrier attack jet, and the EA-6B Prowler electronic warfare aircraft. While the procurement of one very capable new aircraft to replace four old ones appeared to be a match made in Heaven, its introduction into service was not carefully considered. Care should have been taken to ensure that the integrity of all the missions it was to perform was maintained to a level that equaled or exceeded the capabilities of the retired aircraft. Otherwise, the ultimate effect on the capability of the Marine Aviation Combat Element (ACE) would be a net loss.

Marine Aviation Weapons and Tactics Squadron One, better known as MAWTS One, is the Marine Corps agency responsible for establishing doctrine for Marine Air Wing. When the F/A-18D entered service, MAWTS sought to establish training doctrine to incorporate the new

platform. Interestingly, MAWTS did not use the doctrine of the four aircraft that the Hornet replaced as a point to start from. Instead, MAWTS took, verbatim, the training doctrine from the one aircraft that the F/A-18D did not replace, the single-seat F/A-18C. One section was added to the end of the "new" F/A-18D training doctrine incorporating the airborne supporting arms coordination missions that were acquired from the OV-10 and the OA-4M.

The unfortunate decision to use the F/A-18C as the primary doctrinal model for the F/A-18D has not been devastating, but it has lead to inefficiencies in the employment of the new platform and to a lack of training focus for F/A-18D crew members. In the all-weather and night attack role formerly flown by the A-6E Intruder, the F/A-18D offers no hardware advantages over the single-seat F/A-18C. The radar, infrared, and navigation systems are exactly the same. The advantage that the F/A-18D has in this mission is the second crew member, the Weapon Systems Officer (WSO). The doctrine of the single seat F/A-18C in this role would obviously not take advantage of this fact, so herein lies the first inefficiency. The doctrine for the tactical reconnaissance mission formerly flown by the RF-4B Phantom is still forthcoming since the ATARS upgrade to the F/A-18D is scheduled for 1999. The success of this program is yet to be determined.

The greatest inefficiencies have occurred in missions that the F/A-18D took over from the OV-10 Bronco and the OA-4M Sky Hawk, namely, airborne supporting arms coordination. The F/A-18D is a modern digital strike fighter with many advantages and certain disadvantages in comparison to the two aircraft that it replaced in this role. The OV-10 was a twin engine turboprop aircraft that was very fuel-efficient and could remain over the battlefield for over three hours at a time without refueling. It had an outstanding communication suite with four radios, which was much more flexible than the two radios currently in the F/A-18D. On the negative side, the Bronco lacked the digital sophistication and survivability of the F/A-18D. In comparison to the OA-4M, the F/A-18D is generally superior in all capabilities, with roughly

equal time on station, but once again a significant advantage in digital sophistication and survivability. The OA-4M, however, also had a more flexible communication suite than the Hornet. These examples illustrate some of the basic differences between the new aircraft and the old ones. The capabilities and limitations of the F/A-18D dictate that it will carry out its assigned missions in a different manner than the previous platforms. It stands to reason that new doctrine and a new set of standards are developed to ensure that the overall capability of Marine aviation is enhanced by the employment of the F/A-18D.

The Problem

The introduction of the F/A-18D into the Marine Corps was conducted in such a way that inefficiencies in tactical employment were bound to occur. Basing the doctrine of the F/A-18D on that of the F/A-18C was a simple and easy way to get the new platform introduced into the fleet with minimal effort. This same cut and paste approach was used when the OV-10 Bronco was retired. The OV-10 doctrine was taken verbatim and plugged into the F/A-18D manuals. Nearly ten years of apathy has festered in Marine aviation with regard to improving the employment doctrine of the F/A-18D. It is flown and fought exactly like the F/A-18C except on those occasions when it is called upon to exceed the limitations of the "C" model and perform the less glamorous missions for which it was intended. Arguably, the most important of these missions is airborne supporting arms coordination. These missions encompass those formerly performed by the OV-10 Bronco and the OA-4M Sky Hawk. Marine Corps doctrine must be revised and enhanced to take full advantage of the F/A-18D Hornet and to ensure that the platform is providing the best possible support to the Marine Air Ground Task Force (MAGTF). Changes in the employment and training requirements will be necessary to unlock the full potential of this outstanding aircraft.

Purpose

The purpose of this thesis will be to analyze the stated roles and missions of the F/A-18D Hornet in order to determine the most tactically efficient way to employ the aircraft in support of the modern Marine Corps. *Operational Maneuver From the Sea* (OFMTS) represents the Marine Corps' doctrine of the twenty-first century. The initiatives put forth in that essay demand the maximum integration of all of the elements of the MAGTF to dominate the battlefields of the future. Historically, the airborne supporting arms coordinator has provided that critical link which has connected ground, sea, and airborne assets in the MAGTF. That kind of close integration of forces is what gives the Marine Corps its reputation as the World's premier practitioner of combined arms warfare. I intend to prove in my thesis how the effective employment of F/A-18D is critical to the success of *Operational Maneuver From the Sea*. Recognition of this fact now will lead to an improved level of preparedness and proficiency within the MAGTF.

Research Question

This thesis seeks to research and answer the following primary research question:

How can the Marine Corps Best Employ the F/A-18D as an airborne supporting arms coordination platform in support of the MAGTF?

The secondary questions are:

1. Will the airborne supporting arms coordinator be relevant to future MAGTF operations?
2. What tactics, techniques, and procedures will be required of F/A-18D crewmen to best support the MAGTF.

Assumption

I made the following assumption while undertaking thesis research: The F/A-18D will be active in the Marine Corps for at least the next fifteen years. Thus, the need for new and better doctrine for the aircraft is relevant to the future needs of the Marine Corps. The Marine Corps has made the decision not to buy the next generation of naval fighter, the F/A-18E/F Super Hornet series. In so doing, the Corps will skip a generation of fighter design to wait for the procurement of the Joint Strike Fighter, which is expected to be operational in 2010. The Harrier will be the first platform projected to be phased out by the Joint Strike Fighter, followed by the F/A-18C, and lastly the F/A-18D. This should extend the service of the F/A-18D until at least 2015.

Definitions

Before proceeding with further discussion on the specific goals of the thesis, key terms must be defined to enhance the understanding of the roles and missions of the F/A-18D.

Close Air Support (CAS). CAS is defined as air action by fixed and rotary wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces (JP 3-09.3 1995, I-1). In simple terms, the primary reason that the Marine Corps has an air wing at all is to provide air support to the MAGTF. Amphibious operations are not conducive to the devastating employment of artillery forces. Similarly, Naval Surface Fire Support (NSFS) is limited in capability and availability in the modern United States Navy. Battleships that previously provided significant combat power to amphibious assault operations have been retired from active service. As a result, CAS is the primary combat multiplier for the Marine infantry on the modern battlefield.

Marine Air Command and Control System (MACCS). This is the organization that provides the structure of the Aviation Combat Element (ACE). The primary agencies of the MACCS that affect the roles of the F/A-18D are the Tactical Air Command Center (TACC), the

Tactical Air Operations Center (TAOC), and the Direct Air Support Center (DASC). The TACC is the highest-ranking agency within the MACCS and serves as the command center for the ACE. The TAOC is subordinate to the TACC, and provides safe passage, radar control, and surveillance for CAS aircraft in route to and from target areas. The DASC is another subordinate agency that supports the highest Fire Support Coordination Center (FSCC) in managing the CAS war and processes immediate CAS requests from the Ground Combat Element (JP 3-09.3 1995, II-11). The older aircraft that were replaced by the F/A-18D were well integrated into the MACCS. The doctrine that existed at the time allowed the Marine Corps to fully exploit the capabilities of those platforms. Since the F/A-18D has been in the inventory, the integration has suffered due to an inefficient transition to the new aircraft.

Supporting Arms Coordination / Coordinator (Airborne)--SAC(A). SAC(A) is a generic term for one of the primary roles of the F/A-18D. The F/A-18D replaced two aircraft that previously shared this responsibility: the OV-10 Bronco and the OA-4M Sky Hawk. The term "SAC(A)" can refer to the act of supporting arms coordination from the air, or the actual aircraft performing the coordination functions. Three more specific doctrinal terms are used to define the key critical functions of SAC(A) aircraft.

Forward Air Controller (Airborne)--FAC(A). FAC(A) is the doctrinal term used to describe an officer, who from an airborne platform, conducts air reconnaissance and provides terminal control of close air support missions (JP 3-09.3 1995, II-8). The FAC(A) is a member of the Tactical Air Control Party (TACP), which is the aviation fire support team for the Ground Combat Element (GCE). The FAC(A) extends the range that the TACP detect, identify, and destroy the enemy. He will usually support a specific TACP, but can also serve as an additional Forward Air Controller (FAC) to support a maneuver element without a TACP. Prior to the acquisition of the F/A-18D, the FAC(A) mission was divided between two aircraft. The OV-10 Bronco was the "slow" FAC(A) that worked closer to forward lines. It could not venture far into

hostile territory because of its slow speed and vulnerability to the most basic enemy surface to air threat systems. The OA-4M Sky Hawk, was the "fast" FAC(A) that worked deeper over enemy territory due to its greater survivability as a fast jet.

Tactical Air Coordinator (Airborne)--TAC(A). A Tactical Air Coordinator (Airborne) is an officer who coordinates, from an aircraft, the action of combat aircraft engaged in close support of ground or sea forces (JP 3-09.3 1995, II-9). In the Marine Corps, the TAC(A) is an advocate for the Ground Combat Element (GCE) who is provided by the TACC to ensure that the Aviation Combat Element provides timely close air support. The TAC(A) differs from the FAC(A) in that he is not a terminal controller of CAS aircraft. The TAC(A) works on the other end of the close air support spectrum. His mission is to coordinate the flow of CAS aircraft to the forward air controllers both on the ground and in the air. The TAC(A) must have excellent situational awareness of the ground commander's needs, and with that knowledge, facilitate the combat power of close air support to the most critical areas of the battlefield. This mission was previously performed by the OV-10 Bronco.

Strike Coordination and Reconnaissance--SCAR. The last term that applies to the F/A-18D as a SAC(A) platform is SCAR. This term is specific to the Marine Corps and was previously referred to in military aviation as "Fast-FAC." SCAR is a mission flown for the purpose of acquiring and reporting deep air support targets, and coordinating air interdiction or armed reconnaissance missions upon those targets for destruction (MAWTS-1 1994, 125). Generally, the SCAR aircraft works beyond the Fire Support Coordination Line (FSCL). The FSCL is a permissive fire control measure that allows targets beyond the line to be engaged by all means of fire support without prior coordination with the forces on the friendly side of the line. The FSCL prevents fratricide on the friendly side of the line, while permitting the rapid engagement of enemy forces on the enemy side of the line. The role of the SCAR aircraft is to reconnoiter a given zone of the battlefield, locate follow on echelons of enemy forces, and

coordinate the efforts of strike aircraft to engage those targets. This provides a permissive environment for strike aircraft to attack targets in the area without the need for close coordination with ground forces. The SCAR platform can ensure efficient strikes on the enemy because he remains in the area long enough to gain a high level of situational awareness in the zone. This prevents redundant strikes on targets that may have been previously engaged, and helps to quantify the enemy and shape the battlefield. This mission was carried out by the F/A-18D during Desert Storm

Limitations

The F/A-18D is arguably the most versatile tactical combat aircraft in the entire world. There is no other platform in any nation that routinely performs the variety of missions that the two seat Hornet performs. This is due to the multiple role hardware design of the aircraft, the fact that it has two crew members, and most importantly because of the unique demands that the Marine Corps places on this platform. Volumes could be written about how to improve the employment of the F/A-18D in all of the many missions that exist within its repertoire. The research and conclusions in this thesis were limited to the primary mission roles of airborne supporting arms coordination.

Delimitation

The following restraints were imposed upon this research in order to remain focused: The roles and missions of the F/A-18D as they relate to air superiority will not be researched. The F/A-18D inherited the air superiority role by nature of its fighter origins. The F/A-18 Hornet was the first modern aircraft designed to perform both the fighter role of air superiority, and the attack roles of CAS, interdiction, and deep strike. It remains the only aircraft in the United States inventory to have the designation of both "F" for fighter and "A" for attack. The doctrine for air-to-air combat tactics in Naval Aviation are well developed by the Naval Fighter Weapons School, Top Gun.

The training that pilots and weapon system officers receive prior being assigned as crewmen in an F/A-18D squadron will not be researched. This training is standardized throughout naval aviation and provides a good basis for all new flight crew.

Significance of Study

After having spent my entire career in the Marine Corps focussed on fire support for the Marine Air Ground Task Force, I am convinced that the maximizing the potential of the F/A-18D is relevant to the future success of *Operational Maneuver from the Sea*. During Desert Storm, I was a ground based forward air controller attached to the Arab Coalition Division in the eastern most zone of the Kuwaiti theater of operations. Over the course of the combat operations during both the air campaign and the ground campaign, I was responsible for coordinating and controlling thirty-seven close air support missions. Marine, Navy, and Air Force aircraft serviced those missions. The critical link in the overwhelming success of these attacks was the presence of the SAC(A) aircraft that supported my efforts during the conflict. The reconnaissance, coordination, and targeting provided by the OV-10 Broncos and F/A-18D Hornets were absolutely critical to the success of Marine close air support during Operation Desert Storm. SAC(A) aircraft are key elements in supporting the operational fire support needs of the MAGTF today, and will continue to be so on the battlefields of the twenty-first century.

CHAPTER 2

LITERATURE REVIEW

Introduction

In order to complete this thesis I conducted research in three separate phases. First, I conducted research on the history and development of the SAC(A) concept throughout warfare since the first usage of aircraft on the battlefield. Second, I conducted research on the various missions that have been generated over the years as the SAC(A) concept evolved through trial and necessity under combat conditions. Lastly, I conducted research on the physical characteristics and capabilities of aircraft that have been used over the years to perform the role of airborne supporting arms coordinator. This research data was compared to the characteristics and capabilities of the F/A-18D in chapter 4 to assist in determining the answer to the primary research question in chapter 5.

Literature Review Relating to the History of Airborne Supporting Arms Coordination--SAC(A)

Research conducted during this phase consisted of a review of several books, periodicals, and government documents, as well as personal interviews over the Internet and by telephone. There is an abundance of literature pertaining to the use of airpower in general, especially with regard to CAS. Almost without exception, all of the references that review the history of CAS have numerous mentions of the use of spotter planes, airborne forward air controllers, strike control aircraft, and aerial reconnaissance platforms. The United States Army Command and General Staff College Combined Arms Research Library provided several key references on the history of military aviation. These documents contributed the most to my research.

The most useful document I obtained from the Combined Arms Research Library was a book published by the Air University Press at Maxwell Air Force Base, Alabama. The book was entitled *Mosquitoes to Wolves: The Evolution of the Airborne Forward Air Controller*.

Lieutenant Colonel Gary Robert Lester, USAF, wrote the book in 1997. Lieutenant Colonel

Lester accrued over 3000 hours as a Weapons Systems Officer (WSO) flying the F-4 Phantom II. Lieutenant Colonel Lester served two combat tours in Southeast Asia as a Fast-FAC. His book is arguably the most comprehensive work on the subject of airborne supporting arms coordination anywhere in the world. He references the use of airborne supporting arms coordinators from as early as the Italo-Turkish War of 1911 and carries through to Desert Storm in 1991.

Case Studies in the Development of Close Air Support, written by Benjamin Franklin Colling, was a great reference covering the period between World War One through the Arab-Israeli wars of the early seventies. Mister Cooling compiled several essays written by different authors covering each major air power during the period covered. This was especially insightful because it provided several different viewpoints in one reference.

I was able to obtain more specific information about individual conflicts by researching references specific to a given time period. One book was entitled *Forward Air Controller Vietnam: A Lonely Kind of War*. Marshall Harrison, a former Air Force pilot, wrote this book about his experiences flying the OV-10 Bronco during the war in Vietnam. Another outstanding book about flying OV-10 forward air control in Vietnam entitled *Hit my Smoke* was written by an Australian exchange pilot named Chris Coulthard-Clark. These two references were particularly useful because most of the modern techniques, tactics, and procedures for airborne forward air control originated during the Vietnam War.

The best works that I found on the role of the airborne supporting arms coordinator during the Gulf War of 1991 were written by Major Jay A. Stout, USMC, and Mr. William Smallwood. Major Stout wrote a book entitled *Hornets Over Kuwait*, which documented his experiences as a Marine F/A18C pilot flying missions over both Kuwait and Iraq. Although he did not fly as a supporting arms coordinator himself, he flew several escort missions in support of F/A-18D aircraft performing SAC(A) missions. From his perspective, I was able to draw an unbiased view the effect that the airborne supporting arms coordinator had over the battlefield.

Mr. William Smallwood, a civilian pilot, wrote the book *Warthog* about the experiences of the A-10 Thunderbolt II during the Gulf War. He interviewed several pilots about their experiences in the war, which also provided several viewpoints about the success of the A-10 and the OA-10 FAC(A) during that conflict.

Literature Review Relating to the Missions That Have Evolved
Since the First Employment of the SAC(A) Concept

The Combined Arms Research Library and the Center for Army Lessons Learned have extensive databases on subjects relating to CAS and all of its related missions. The United States Air Force Air Ground Operations School was a great source of information. These three sources provided several useful references in the form of after-action reports from exercises like National Training Center at Fort Irwin, California, and Air Warrior at Nellis Air Force Base, Nevada. Almost all of the information provided by these sources was in the form of computer databases from Internet web sites. Additionally, these sources provided access to several military articles and documents that have been written over the years with regard to changing opinions on the employment of close air support.

Most of the research that was done in this phase came in the form of reading all of the historical information on the subject of CAS and airborne supporting arms coordination. From each reading, I pulled the relevant information out that indicated what missions that airborne supporting arms coordinators have performed throughout the different conflicts in which they have been employed. From this effort, I compiled a list of distinguishable missions that they have performed in support of the employment of airpower on the battlefield.

The after-action reports that I found offered not only historical accounts of how air controllers performed in the past, but also provided insightful new ways that they can have a positive impact on the battlefield. This provided me with additional information from which I could derive the potential missions that an airborne supporting arms coordinator could perform in combat. The after-action reports also served to validate the importance of the missions that such

aircraft perform in the training environment. By validating the missions in training, the way is paved for airpower doctrine to include the effective employment of the airborne supporting arms coordinator.

Literature Review Relating to the Characteristics and Capabilities of the
Aircraft That Have Been Employed in the SAC(A) Role

The final phase of my research focussed on determining the physical characteristics and capabilities of the aircraft that have been employed throughout history as airborne supporting arms coordinators. This phase of my research was perhaps the most critical since my ultimate goal was to suggest the best method to employ the F/A-18D as a SAC(A) platform. By studying the characteristics of aircraft that have served in the SAC(A) role in the past enabled me to compare them to the F/A-18D to determine what the best employment options were. The F/A-18D's strengths and weakness compared to the other aircraft helped to determine what its limitations are in the conduct of the various missions.

Jane's All the World's Aircraft is an encyclopedia of aircraft that is published every two years. It is one of the best sources of detailed information available on the different types of aircraft that have been produced since the beginning of aviation history. Each edition of the encyclopedia has a very useful index of what is covered in the previous ten editions. The index is broken down into a primary covering the contents of the current edition, and a separate index for all the aircraft that exist within its database. From there I found out which edition had detailed information on the aircraft that I was looking for.

All four of the services have web sites on the Internet that provide detailed unclassified information on the various combat systems that they employ. Some of the services, especially the Air Force, maintain a database of aircraft that have been retired from active service. I was able to find just about every former SAC(A) platform used by the Air Force since the Korean War. On the Internet, there are several civilian aviation enthusiasts that have developed their own web sites

with collections of historical aircraft. The Internet is also home to several web sites that are maintain by former military pilots that are specific to the planes that they flew.

The Discovery Channel has a television series called "Wings," which features one-hour programs on past and current aircraft. The series covers the factors that lead to the development of each aircraft, the design specifications, and the success of the aircraft after it was fielded. One of the episodes was devoted entirely to forward air controllers of the past. I also reviewed a set of aviation related CD ROM disks created by the Discovery Channel that contain a database of hundreds of previous military aircraft. The Discovery Channel web site also has a database of aircraft that also provided very useful research information.

Lastly, I discovered two publications called *World Air Power Journal* and *Wings of Fame*. These periodicals are published quarterly, and contain a thirty-page study of their featured aircraft in each issue. The *World Air Power Journal* covers current aircraft and *Wings of Fame* covers historical aircraft. These two publications were also useful for their historical accounts of the aircraft and their contribution air power.

The greatest difficulty that I experienced in the course of my research was in obtaining detailed after action reports on the employment of airborne supporting arms coordination aircraft during Marine combat or training operations. Unlike the Air Force, the Marine Corps does not maintain detailed archives of aviation related lessons learned. Marine Aviation Weapons and Tactics Squadron One and the Marine Corps Doctrine Division were not able to provide the level of useful information on CAS and airborne supporting arms coordination that was available from the Air Force Air Ground Operations School.

CHAPTER 3

METHODOLOGY

Introduction

The methodology used consisted of a straightforward approach to determine the answer to the primary research question of how to best employ the F/A-18D as an airborne supporting arms coordination platform. My goal was to find an objective method to come up with answers that were both sufficient and feasible. I wanted to build a foundation from which to develop a set of criteria that I could use for evaluation and comparison. I needed my research to follow a simple and logical flow that would ultimately guide me to the best solution to the problem.

I decided that a simple method of determining the most effective way to employ a modern weapon system was to evaluate any historical references that validate the need for such a system. This provided the foundation for the rest of my research. After completing the historical study, I determined the mission requirements that lead to the introduction of the weapon system and its evolution. From there, the system was compared to other like systems that performed similar mission functions. The completion of the analysis produced enough data to suggest the most efficient way to employ the F/A-18D within its limitations. Any flaws in the system that could be corrected were also explored to suggest possible improvements.

Step 1: Validate the Necessity for the Airborne Supporting Arms Coordinator through Historical Analysis

The first step was to conduct a historical study of the employment of airborne supporting arms coordination platforms. Beginning with the first historical references to aircraft used in support of military operations, I researched each major combat action. I attempted to draw out the relevant information that served to validate the need for airborne SAC(A) aircraft in combat operations. Each war introduced new technology and new doctrine to the battlefield. These advances had a significant effect on the evolution of the types of machines that flew the missions,

and the techniques, tactics, procedures that they employed. As I had hoped, the historical analysis provided the basis for the remainder of the thesis.

Step 2: Determine the Mission Requirements that the Airborne Supporting Arms Coordinator Must Perform on the Battlefield

The historical study of the different conflicts provided various sets of circumstances and scenarios, which shaped the requirements placed on the aircraft that flew in support of the different operations. Since the role of the airborne supporting arms coordinator grew out of the needs of ground forces in combat operations, many of the mission requirements are directly related to supporting land forces. As doctrine, technology, and operational necessity developed over the years, the airborne supporting arms coordinator began to take on a wider variety of missions. Several different aircraft were called upon to perform various tasks within the mission category. Not every individual aircraft was adept at all the supporting arms coordination tasks, but collectively they helped to determine what missions defined the category.

From my study, I determined that there were several mission requirements that fall within the category of airborne supporting arms coordination. The requirements were broken down into the eight mission essential tasks that are listed below:

1. Observation
2. Radio Relay
3. Reconnaissance in Direct Support of Ground Forces
4. Reconnaissance in Support of Deep Operations
5. Command and Control
6. Terminal Control of Indirect Fires (artillery, mortars, naval gunfire)
7. Terminal Control of Close Air Support (fixed wing and rotary wing)--FAC(A)
8. Terminal control of Deep Air Support (strategic strikes and air interdiction)--SCAR

These eight mission essential tasks are analyzed in detail in chapter 4. Each of the eight requirements was individually defined and evaluated to determine what duties that the airborne supporting arms coordinator had to perform to be successful in the particular mission area. I also determined that there were four characteristics that affected the ability of a particular aircraft to perform the various SAC(A) mission tasks:

1. Survivability
2. Endurance
3. Communications
4. Aircraft Systems

Step 2 helped me to determine the basic mission requirements of the SAC(A) and the desired characteristics and capabilities of the aircraft that were used to perform airborne supporting arms coordination. By breaking down the analysis in this fashion, I was able to establish objective criterion that could be applied to each aircraft chosen for comparison in Step 3 of my methodology.

Step 3: Compare Past and Present Airborne Supporting Arms Coordination
Platforms to the Mission Requirements

I decided in Step 3 to choose a select group of aircraft that performed in the airborne supporting arms coordination role which covered a large time period in military aviation history. I wanted to insure that the aircraft used for my comparison flew in a wide range of tactical scenarios and operational requirements. I chose to select the aircraft which performed best at the SAC(A) role in each of the last three major wars that involved United States air power. Specifically, I looked at the Korean War, the Vietnam War, and Desert Storm. Conceding that determining which aircraft was "best" in each conflict would be too subjective, I settled on selecting the aircraft which were the most prolific platforms used for airborne supporting arms coordination for the given period.

The T-6 Mosquito began its career as an unarmed trainer for the United States Air Force and Navy after World War II and was known as the T-6 Texan. It was called into action in Korea as the "Mosquito" to support ground forces and performed a myriad of tasks as the war progressed. The use of the T-6, and the tactical conditions that the conflict presented, helped the Air Force to develop many of the modern techniques, tactics, and procedures for SAC(A) employment. Study of the Mosquito also provided insight into the characteristics and capabilities necessary to perform the mission.

The OV-10 Bronco was perhaps the most successful airborne supporting arms coordination platform ever employed by the United States. It was the only aircraft in our modern aviation history that was purpose built and designed to perform the SAC(A) role. The Bronco served the Air Force, Navy, and Marine Corps in the Vietnam War, and continued in service twenty years later with the Marines in Desert Storm. Study of the Bronco provided the most comprehensive insight into the requirements and characteristics necessary to perform as an airborne supporting arms coordination platform.

The OA-10 Thunderbolt II is an adaptation of the standard A-10 attack aircraft used by the Air Force since the early Seventies. It was the designated replacement for the OV-10 when the Bronco was retired from active Air Force service. Although the airframe is identical to the standard A-10, OA-10 squadrons have a specific mission designation to perform as airborne forward air control platforms. It is currently the only aircraft in the military dedicated specifically to fill such a role. The OA-10 also served in Desert Storm in support of United States Army and Marine Forces. The aircraft continues to support Army forces in numerous tactical exercises and is the primary source for SAC(A) doctrine within the Air Force.

The AH-1W Cobra provides rotary wing close air support for the Marine Air Ground Task Force. It ranks as one of the finest attack helicopters in the world. The Cobra was a star performer during Operation Desert Storm, exceeding the readiness rates of the Army's famous

AH-64 Apache. When the OV-10 was retired from Marine Corps service, the Marine Light Attack Helicopter (HMLA) community was tasked to share the FAC(A) and TAC(A) roles with the F/A-18D. The Cobra, along with UH-1N Huey, was to be the new "slow" FAC(A) to compliment the Hornet in the Fast-FAC role. Together, the helicopters and the Hornet were to perform all of the missions previously performed by the OV-10 and the OA-4M.

Lastly, I evaluated the F/A-18D Hornet, which was the focus of my thesis. Designed as multi-role strike fighter to serve the needs of the Marine Corps, the F/A-18D entered service in 1989. The aircraft was a two-seat adaptation of the single-seat F/A-18C, which is the mainstay of the United States Navy and Marine Corps supersonic strike fighter fleet. The aircraft received its baptism by fire in Desert Storm in the role of what was then referred to as Fast-FAC or fast forward air controller. In this role, it replaced the OA-4M Sky Hawk which had been retired from service. The F/A-18D also picked up the roles and missions of the OV-10 for the Marine Corps when the Bronco was retired after Desert Storm. The F/A-18D is the only fast jet in the comparison. This fact enabled the study to include the full spectrum of aircraft types. It also helped to determine how the different physical characteristics and capabilities of this wide range of aircraft types contributed or detracted from their ability to perform the SAC(A) mission.

Each of the aircraft selected for the comparison was evaluated against the eight mission essential tasks and four aircraft characteristics determined in Step 2. This evaluation highlighted the strengths and weaknesses of each platform in the various tasks. In every case, the leaders and aircrew that flew them took steps to overcome the weaknesses, and maximize the strengths of their platforms. This provided insight into possible solutions to the primary research question.

Step 4: Conclusion

The last phase in my methodology was to focus on the F/A-18D and the data that was obtained from the three previous steps. By comparing the mission requirements of the SAC(A) mission to the various aircraft, I had ample data to suggest solutions to how to best employ the

F/A-18D. In addition to techniques, tactics and procedures, I was able to also explore options that may serve to improve the capabilities of the aircraft itself.

The mission requirements of the SAC(A) that were determined in Step 2 are all elements of the three bold mission categories that exist in current doctrine. The three SAC(A) mission categories are currently defined in Marine Corps as:

1. FAC(A)--Forward Air Controller (Airborne)
2. TAC(A)--Tactical Air Coordinator (Airborne)
3. SCAR--Strike Coordination and Reconnaissance

I wrote a separate section in my concluding chapter on how to best employ the F/A-18D in each of the three doctrinal mission categories. Each section can be taken as a separate document and used as a guide to the most efficient and effective employment of the F/A-18D in the given category. The three sections should be useful to any Marine involved in any way with the employment of the F/A-18D as a SAC(A) platform.

My research led me to another realization with regard to F/A-18D employment in the SAC(A) role. Although the most critical problem posed by the primary research question was how the Marine Corps as a whole should employ the F/A-18D at the macro level, there was also a need to suggest specific techniques, tactics, and procedures to the aircrew that fly the missions. I decided to add Appendix A to my thesis, which is designed to provide specific guidance to aircrew on how to employ the F/A-18D as a weapon system while performing airborne supporting arms coordination.

CHAPTER 4

ANALYSIS

Introduction

The analysis will be conducted in three distinct steps as described in chapter 3. Step 1, the historical study, will provide the background information and justification for the use of airborne supporting arms coordination aircraft. Step 2 will draw the relevant mission requirements and aircraft characteristics from the historical study, which will serve as the criteria for the next step. The third step will be to individually evaluate the five selected aircraft against the criteria to determine the strengths and weaknesses of each and to provide objective data to answer the primary research question.

Historical Background: The Evolution of the Airborne Supporting Arms Coordinator--SAC(A)

The roles and missions of the F/A-18D can be traced back over two hundred years. A review of the contributions of military aviation is required to gain a full understanding of how supporting arms coordination aircraft can be a force multiplier for ground forces.

The first historical reference of an army using an airborne platform to assist in operations against an enemy force dates back to the Napoleonic era. In 1794, a French balloonist went aloft to observe Austrian and Dutch troops (Hightower 1984, 25). The mission of this pioneering airman was aerial reconnaissance of the enemy to give his commander an information advantage over the opposing force commander. Since the enemy force did not have an airborne platform to exploit the bird's-eye view of the battlefield, it could also be said that the French provided the first example of air superiority. Air superiority is a primary requirement for close air support.

The first known occurrence of an aircraft attempting to inflict casualties on the enemy was during the Italian-Turkish War of 1911 and 1912. An Italian pilot dropped three small bombs on Turkish positions in November of 1911. The Italians continued to bomb Turkish positions from aircraft and airships throughout that conflict. Bombing from aircraft also occurred

in the Balkan Wars. The effectiveness of air support during these wars was largely ineffective. The bombing was random and indiscriminant, often at the initiative of the individual pilots. During this same period, the Colonial French Army began using aircraft in North Africa against Moroccan tribesman. These air operations were different, however, because they involved cooperation between the aircraft and ground forces (Lester 1997, 1).

World War I introduced new uses for aircraft in coordination with ground forces. Due to the nature of trench warfare, aircraft became an essential part of the effort to accurately plot the enemy positions. Observation airplanes carried cameras into battle to help map out the details of the enemy trench networks. Trench warfare was also responsible for the emergence of the artillery spotter aircraft. Artillery barrage fires against the trench lines had been largely ineffective prior to the air spotter. The Germans were first to take advantage of the airborne spotter concept. They formed fourteen aviation spotter units to undertake the task. The Germans wanted to have an artillery spotter unit for each of its frontline divisions. By 1916, these artillery spotter units made up forty-five of eighty German observation units (Lester 1997, 3).

In 1915, both Allied and German forces employed a new concept of air support, the *infantry contact patrol plane*. The role of the contact patrol plane was to follow the progress of the friendly infantry units and fill in the communication gaps that developed when communications between ground units were lost. These aircraft became the eyes and ears of the infantry. At times they attacked enemy columns, but this was done on their own initiative, not as part of an integrated plan with the ground forces. There was some resistance to the contact patrol planes because ground units feared that the aircraft circling above the friendly forces would give away their positions, making them vulnerable to artillery attacks (Lester 1997, 4).

The British were the first to use aircraft in the dual-purpose role of close reconnaissance and destructive bombardment. The Royal Flying Corps assigned eighteen aircraft to the role in 1916 at the Battle of Somme (Lester 1997, 4). The British realized that aircraft could be just as

adept at attacking enemy forces as they were at following the friendly units in the role of contact patrol.

The Royal Flying Corps low-altitude air attacks were closely coordinated with the movement of the ground forces by 1918. One of the lessons learned was that air support aircraft had a great effect on the morale of the troops on the front lines. For the enemy, it was a great demoralizer. For the friendly side it was a great motivator. It was found that the aircraft armed with .30-caliber machine guns, grenades, and small bombs had little effect on fortified locations. (Lester 1997, 4).

Toward the end of World War I, air support had two categories of targets. First, there were the targets located near the front lines. These were usually well defended. Second, there were those targets that were considered beyond the "crust," which was considered to be the area beyond the range of the artillery. These targets were usually less defended, and thus very vulnerable. Since only aircraft could reach these targets, there was considerable opinion growing that attacking targets beyond the crust was the best use of aircraft on the battlefield; air interdiction vice close air support.

The technology of aircraft improved between the wars. Military leadership in the United States began to consider doctrine for the future roles of aircraft in supporting ground forces. The Marine Corps lead the way in improving the coordination between air and ground forces during operations in Nicaragua. Marine aircraft served as airborne artillery for the infantry. Flying escort for march columns moving through the jungle, the Marine aircraft were able to work in areas that offered very little separation between friendly and enemy forces. They were closely integrated with the movement of the infantry, and were very effective at breaking up enemy attempts to ambush the Marines (Moskin 1992, 160). The experiences in Nicaragua defined the enduring philosophy of Marine aviation.

Navy and Marine close air support was perfected during World War II. Closely controlled air strikes were critical assets during the amphibious advance across the Pacific. Air liaison teams traveled with frontline infantry units, while spotter liaison aircraft supported from above. Together, they assisted the ground commanders in selecting targets and coordinating strikes from attack aircraft. Senior aviators who were intimately familiar with the ground scheme of maneuver flew the liaison aircraft. They maintained radio contact with the fighter-bombers to provide quick response. This system was tested on Tarawa and Iwo Jima, but was not truly perfected until the Battle of Okinawa (Moskin 1992, 399). By the end of the war, the Navy-Marine system was a well-oiled machine. Aircraft quickly and accurately delivered ordnance in close proximity to forward ground elements under close control of air and ground liaison teams. These procedures set the stage for the Korean War where the battle at the Pusan perimeter revealed three major differences in Air Force and the naval services with regard to CAS: philosophy, technique, and language.

The National Security Act of 1947 established the United States Air Force as a separate service from the Army. The Air Force philosophy was that airpower should be focussed primarily against the enemy's war making potential, and secondly to the immediate battle area where ground forces are engaged. The Navy-Marine Corps view was that airpower should be used to attain any given objective vital to victory, and regarded close air support as indispensable for the ultimate defeat of the enemy (Lester 1997, 32).

Navy-Marine close air support techniques required pilots learn to read terrain and understand the capabilities and limitations of ground weapon systems. With this knowledge, air liaison officers could coordinate air strikes very close to friendly forces. Air Force pilots did not receive the same degree of training. With regard to the control of air power, Marines had thirteen tactical air control parties per division. The Air Force only provided four such teams to Army divisions. The Marines believed that the front line commander should have direct access to air

support. The basic presumption was that if close air support was not responsive within ten to fifteen minutes, it was of little value to the front line units. The Air Force believed that control of aircraft should never degenerate to ground commanders who have limited perspective of the battle (Lester 1997, 17).

The third major difference between the two services was in their interpretation of the definition of close air support. The accepted definition for CAS was: "Air action against hostile ground or naval targets which are so close to friendly forces as to require detailed integration of each air mission with the fire and movement of those forces." The naval services defined "close" as 50 to 200 yards immediately in front of friendly troops. The Air Force considered "close" as within several thousand yards in front of the line, or the distance to which field artillery could effectively reach (Lester 1997, 18).

Lieutenant General Lemuel C. Shepherd, commanding general, Fleet Marine Force Pacific, best summarized these differences in 1951: "We believe in providing for a small number of on-station planes; the Air Force does not. We believe in continuous direct communication between the frontline battalion and the controlling agency; the Air Force does not. We believe that close air support of the frontline troops should take precedence over routine interdiction missions; the Air Force does not" (Lester 1997, 18).

The Air Force concluded that tactical airpower should be centrally controlled. The system relied less on liaison officers on the ground traveling with the infantry, and more on airborne controllers. While this centralized concept was very different than the Navy-Marine system, the terrain and conditions in Korea would make these airborne controllers invaluable. The mountainous terrain made ground communications difficult. Additionally, ground forward air controllers had to travel in jeeps due to the overwhelming size of the radios of the time. The terrain was not only an impediment to communications, it was very hard on the over laden

communications jeeps themselves. The combination of these factors made the airborne controller a vital part of the close air support equation in Korea (Lester 1997, 57).

The Air Force first began using a light liaison aircraft as an air controller that it borrowed from the Army known as the L-5. The L-5 quickly proved to be inadequate for the job due to its slow speed and vulnerability to ground fire. The Air Force switched to the T-6 Mosquito trainer aircraft. The T-6 was a robust 200-mile per hour aircraft of World War II vintage, equipped with rockets and a decent radio. The stated mission of the T-6 was to conduct tactical reconnaissance of front line positions, monitor enemy lines of communication, locate targets, and control air strikes near friendly forces as directed by the 8th Army. One of the most important contributions of the T-6 Mosquitoes was communication relay for the dispersed ground forces. This provided critical links between commanders and their forward elements. They were known as tactical air coordinators-airborne or *TAC-A* (Lester 1997, 68).

The success and flexibility of the T-6 caused the Air Force to expand its roles. Among these roles were deep penetration reconnaissance, convoy escort, and distributing leaflets. Crews began carrying cameras for photo-reconnaissance missions. The Mosquito's slow stall speed and fuel efficiency enabled it to loiter over the battlefield, sometimes for up to six hours at a time. Its rugged simplicity and durability allowed pilots to remain close to forward lines and perform their mission under hostile fire. One disadvantage of the T-6 was that it had no armament with which to protect itself. It was determined that FAC aircraft should carry a nominal bomb load and machine guns to both defend itself and provide an immediate offensive capability to attack ground targets if strike fighters were not available. The improvements to the Mosquito both in hardware and tactical employment made it an invaluable force multiplier for the war effort. In the first eighteen months of the war, 93 percent of close air support sorties were controlled from the air by TAC-A T-6 Mosquito TAC-As (Lester 1997, 70).

As the Korean conflict continued, losses began to take their toll on the T-6 force. The enemy became more adept at targeting the relatively slow and low flying Mosquito. A new concept was integrated into the close air support system, the *pathfinder*. The pathfinder element was made up of the lead flight of a group of jet fighter bombers. In a high threat environment, deeper in enemy territory where the T-6 was at risk, the first flight of fighters to respond to a threat would scour the target area. Once a target was sighted, the pathfinder would strike first then call the other fighters in to attack. The target would be identified by the bomb impacts of the lead fighters. This technique proved quite effective. As the war came to a close, the Air Force concluded that in the future, high performance aircraft would be used as air controllers utilizing the pathfinder tactics. This reaction did not please the Army after the outstanding support of the closely integrated actions of the T-6 Mosquito throughout the war. The Mosquito had been able to linger over the battlefield for hours, providing ground commanders with a tactical comfort level that insured rapid response for immediate air support. The pathfinder concept was aimed at interdiction strikes far beyond the realm of the ground troops. Interdiction was considered by the Air Force to be a more effective use of air power. The TAC-A mission was a low priority for the Air Force at the end of the Korean War.

Vietnam would reassert the importance of the SAC(A) concept. The war in South East Asia had no distinguishable boundaries and no front lines. This resulted in ground units being widely dispersed over the battlefield. CAS strikes had to be executed with extreme precision to prevent fratricide due to the difficulty in distinguishing friend from foe in the dense jungle terrain. The Air Force and the Marines were never more committed to the SAC(A) concept as during the war in Vietnam. Although several large battles occurred during the war, the conflict was dominated by numerous isolated firefights with North Vietnamese Army (NVA) or Viet Cong (VC) forces that normally lasted less than twenty minutes. This situation demanded very responsive CAS.

The problem that these small "troops in contact" situations presented was that jet attack aircraft could not loiter over head friendly forces long enough to first sort out the exact location of the combatants and then deliver their ordnance. The Air Force quickly realized that a middleman was necessary to provide efficient and effective support. The airborne forward air controller or FAC(A) had to be able to loiter over the battlefield for hours, maintaining constant contact with friendly forces on the ground. He could then coordinate immediate support from strike aircraft when required. The Air Force and the Marines began the war using the Cessna O-1 Bird Dog spotter plane armed with 2.75-inch, white phosphorous marking rockets. The Bird Dog was very effective at supporting ground forces. It could remain overhead for three hours, stay in communication with the ground forces, and provide precision marking for CAS strikes. It was, however, slow, vulnerable to ground fire, and unarmed. Forward air control aircraft progressed to the twin-engine Cessna O-2 Sky Master, which was faster and more survivable, but shared many of the weaknesses of the Bird Dog (Lester 1997, 112).

The Marine Corps and the Air Force embarked on a joint project to acquire a purpose built SAC(A) platform. The result was the OV-10 Bronco. The Bronco was a twin-engine turboprop, armed with four rocket pods and four 7.62-millimeter machine guns. It could fly at speeds less than 100 knots, dive at speeds over 300 knots, and climb rapidly out of harm's way. The Bronco was perfectly designed for Vietnam. The impact on the war by the introduction of the OV-10 was significant. Seventy-four percent of OV-10 responses to calls for air support came in five minutes or less. Ordnance delivered by subsequent strike aircraft came in less than ten minutes (Lester 1997, 113). The fact that the OV-10 was given the authority to divert strike aircraft from routine interdiction missions enhanced the responsiveness of CAS. Often times, the Bronco had enough organic firepower to be the decisive factor in a call for help. The missions of visual reconnaissance, radio relay, convoy escort, command and control, and artillery adjustment carried over to the Bronco from wars past.

Visual reconnaissance missions by OV-10s proved to be absolutely essential in extending the range that ground forces could detect, identify, and target the enemy. Ground forward air controllers were severely limited by the denseness of the jungle foliage. Marine and Air Force FAC(A)s routinely flew below 1,500 feet to locate enemy positions and report them to ground commanders. FAC(A)s were able to directly assist commanders in the tactical employment of their forces through reconnaissance and radio relay (Harrison 1989, 68). As the war progressed, the OV-10's capability was enhanced by the addition of binoculars, infrared optics, air delivered flares, and hand-held cameras.

The Marine Corps and the Air Force expanded the role of FAC(A) aircraft to include independent operations away from friendly forces to locate targets for interdiction aircraft and assist in the battle damage assessment (BDA) for those strikes. Targets further north in Vietnam, such as bridges and infrastructure, were usually heavily defended. Slow aircraft, such as the OV-10 could not operate in this high threat environment. Both services turned to jet aircraft to act as Fast-FACs for these strikes, as had been done in Korea. The Air Force chose a two-seat version of a single-seat fighter: the F-100F Super Saber. This aircraft was very fast and maneuverable and carried additional fuel tanks, 5-inch Zuni rocket launchers, and four 20-millimeter canons. The F-100F was well suited to provide strike control and targeting for follow-on strike aircraft in a high threat environment. These strike control aircraft had to have two seats since they were forced to accomplish in seconds what OV-10 FAC(A)s further south had a minute or two to complete. Simple actions, such as navigation and map reading, required two people. Strikes controlled by F-100Fs were twice as effective as those not controlled by strike control aircraft (Lester 1997, 174).

The Marine Corps had an outstanding Fast-FAC program in Vietnam. The first dedicated Marine Fast-FAC missions were flown in late 1966 in A Shau Valley by two-seat TF-9F Cougars of Korean War vintage. The aircraft's limited endurance and poor communications hampered the

crews. In the fall of 1967, the Marine Corps chose the TA-4F, a two-seat version of its primary light attack platform, the single seat A-4 Sky Hawk. The TA-4F had much better endurance, speed, maneuverability, visibility, and an FM radio. Called "Playboys," they were used in a role termed *VR/TAC(A)* or Visual Reconnaissance / TAC(A). Each Marine air group of the 1st Marine Air Wing had its own TA-4F *VR/TAC(A)*s. They had a devastating affect on the enemy supply routes coming out of central Laos into the western edge of the I Corps sector. Their high-speed low altitude tactics made it impossible for North Vietnamese anti-aircraft gunners to react in time to effectively engage them. They perfected the "hammer" tactic of leading a deep strike with a TA-4F at tree top level to achieve tactical surprise, and navigating to the target area with their expert knowledge of the terrain. When enemy gunfire erupted, the *VR/TAC(A)* would drop flares and execute a high "G" pull-up to a perch from which he could locate the target and simultaneously commence a dive to mark it with a smoke rocket. Strike aircraft escorting the TA-4F at a higher altitude would then roll in and destroy the primary target and the enemy gun positions. Lastly, a RF-4B photo-reconnaissance aircraft would make a photo pass of the target within one minute of the bombs exploding for battle damage assessment (Adkinson 1986, 96).

The exploits of the Playboys during the war were legendary. They controlled and coordinated the dozens of strike aircraft stacked up awaiting roll in clearances overhead the besieged Marine base at Khe Sanh. During Operation Dewey Canyon in 1969, one of the most successful operations of the war, they contributed significantly to the 9th Marines, who were heavily engaged against North Vietnamese regulars along the South Vietnam-Central Laos border. They helped identify enemy supply areas, locate and destroy heavy mortar and rocket positions, and provided a badly needed communications link between the DASC and ground forces. After action reports of the ground commanders in Dewey Canyon strongly confirmed the fact that NVA artillery and mortars would not fire while *VR/TAC(A)* aircraft were in the vicinity (Adkinson 1986,97). Both the Marine Corps and the Air Force continued to make effective use

of both fast and slow FAC(A)s during and following the Vietnam War. The SAC(A) tactics, techniques, and procedures developed in Vietnam were put to the test in the Gulf War against Iraq in 1991.

When the Gulf War began, the Marine Corps had the most capable SAC(A) force in its history. The venerable OV-10 had been upgraded with an integrated infrared, laser capable turret, and upgraded engines. The Bronco was now a true night capable platform. Marine helicopter light attack (HMLA) squadrons made up of AH-1W Cobras and UH-1N Hueys also provided SAC(A) services to the Marine infantry. Lastly, a new aircraft entered the scene, the F/A-18D. The single-seat F/A-18 Hornet had served for several years as the Corps' primary strike fighter. A new two-seat version of the Hornet, the F/A-18D, had been developed to replace the A-6E, the RF-4B, and the OA-4. The A-6E had not yet been retired from service, and was still available to bear the load of night attack duties. The decision was made by the leadership to use the F/A-18D exclusively in the role of Fast-FAC, known now as SCAR (strike coordination and reconnaissance) in Marine terminology.

The OV-10 and the helicopters excelled in providing supporting arms coordination in close proximity to Marine forces. The OV-10 was particularly effective as a miniature airborne command and control platform for the forces on the forward lines. The Broncos typically flew three-hour missions, and were cycled to insure that support was available twenty-four hours per day. This provided critical communication links with all task forces, and quick response to all requests for CAS (Culbert and Gamboa 1991, 98). SAC(A) support to the Marine infantry was complimented by the presence of the F/A-18D. In the early stages of the war, strike aircraft concentrated on easily identified strategic targets such as power plants, bridges, railroad yards, and refineries from fairly high altitude. As the war progressed, target priorities shifted to interdiction strikes against staging areas, bunker complexes, and armored vehicles in defensive positions.

The air planners had organized the interdiction effort into free fire areas or "kill boxes" delineated by latitude and longitude lines. Heavily armed interdiction aircraft had minimal endurance to search for targets of opportunity in established kill boxes. They could potentially drop on targets that had already been hit by previous strikes. The F/A-18D Fast-FACs would roam the kill boxes each day and became familiar with all of the targets in the area. As strike aircraft proceeded north into the kill boxes, they were handed off to a Fast-FAC, who would guide them in to active targets (Aerospace Daily 1991, 98). This made the Marine interdiction effort very efficient and effective at shaping the battlefield for the impending ground assault.

The Air Force learned this lesson the hard way. OA-10 Warthogs provided FAC(A) support to Army in close proximity to the forward lines. Forgetting the lessons that had been learned during Korea and Vietnam, the Air Force began the war without a dedicated Fast-FAC to support deep operations. F-16 fighters conducted most of the interdiction missions for the Air Force. Their tactics brought them into the kill boxes well above 20,000 feet, which was generally much higher than the tactics employed by Marine aircraft. This may have been due to the fact that the single-engine F-16 is much less survivable than the twin-engine F/A-18s and A-6s flown by Marines for ground attack missions. In fact, after dropping their bombs on interdiction strikes, Marine F/A-18s would descend below 1000 feet while strafing Iraqi armor. Despite these tactics not a single Marine Hornet was lost to ground fire (Stout 1997, 167). Such tactics were unheard of for F-16s in the Gulf War, and were strictly forbidden by Air Force leadership.

Air Force high altitude tactics compounded the problem of being able to accurately target Iraqi ground targets. F-16 pilots routinely dropped their bombs not knowing if the targets were active unless their attack produced secondary explosions. Five weeks into the air campaign the Air Force decided that Fast-FAC aircraft were needed to end the wasteful bombing. Called "Pointer FACs" or "Hunter-Killers," they consisted of a pair of F-16s that would orbit over a kill box, one looking for targets while the other cleared his path. Once a target was found, the Pointer

FAC would mark the target with his ordnance, which were usually 500-pound Mk-82 bombs. The F-16s could not carry marking rockets like the A-10, OV-10, and F/A-18D SAC(A) aircraft. Other F-16s on station would flow into the target area with larger bomb loads. This technique was nearly identical to the pathfinder operations conducted by the Air Force during the Korean War (Sizemore and Naumann 1991, 125).

The lessons learned during Desert Storm have carried over into the training exercises of both the Marine Corps and the Army/Air Force. The National Training Center at Fort Irwin, CA is where the Army and Air Force validate their close air support doctrine several times a year. The SAC(A) after-action comments speak for themselves. "We observed effective use of the OA-10 FAC(A)s for intelligence gathering and targeting through much of the rotation. Many times the Army intelligence sources were benefited by this real time information from the FAC(A). Not only did they employ CAS more effectively, but they validated the value of the FAC(A) on the battlefield for the Army" (Air Warrior 1996, 4.3.5). "The FAC(A) was again proven to be a valuable link between the Army and CAS aircraft. The fighters would not have been able to locate hard to see target without a mark. On one occasion, the FAC(A) was on the Army fire support frequency giving calls for fires and adjusting the artillery impacts" (Air Warrior 1996, 3.2.1). "During Exercise 98-06, the 34th FS deployed with F-16s FAC(A)s which can detect moving armor formations with the APG-68 radar while standing off approximately 20 miles, the F-16 can provide battlefield awareness and intelligence without undue exposure to threats" (Air Warrior 1998, 3.1).

From 1794 when the French balloonist took to the air to spy on the Austrians to the digital battlefield of Desert Storm, one of the primary necessities for the effective use of air power has been to designate an aircraft the responsibility for coordinating with ground forces, and locating targets for destruction by other aircraft and indirect fires. History must not be ignored with regard to the importance of the airborne supporting arms coordinator on the battlefield.

Since Desert Storm numerous after-action reports from the Army's National Training Center and the Marine Corps Air and Ground Combat Center have reinforced the fact that modern close air support is not nearly as effective without SAC(A) aircraft in support.

Marine Corps aviation has lead the way in the employment of the SAC(A) concept. The outstanding success of the F/A-18D during the Gulf War was due to the very experienced crews that stood up the first squadron, and the fact that the aircraft was not required to perform most of the close support, long endurance missions then performed by the OV-10. Now that the Bronco is retired, the doctrine for the employment of the airborne supporting arms coordinator must be improved to guarantee the continued success of the Marine Air Wing in support of the MAGTF. The SAC(A) mission is now broken up between the F/A-18D and the light attack helicopter community of Cobras and Hueys. This task organization poses new challenges which have not been adequately addressed since Desert Storm. Though technology will continue to provide advancements in air power, the Marine Corps must never lose sight of the fact that the airborne supporting arms coordinator is the glue that maintains the bond between air and ground in the Marine Air Ground Task Force.

Mission Requirements: Definition of the Eight Mission Essential
Tasks of the Airborne Supporting Arms Coordinator

The historical analysis of the airborne supporting arms coordinator revealed that aircraft performing in this role were required to perform a myriad of tasks. As air power was exploited in combat operations, the role of the SAC(A) evolved into eight critical and distinct mission essential tasks.

Observation

Observation is the employment of the airborne supporting arms coordinator as an extension of the ground commander's ability to survey the disposition of his forces in relation to each other and the terrain that they occupy. Essentially, the SAC(A) provides the ground commander with the bird's-eye view of the battlefield. This requirement dates back to the earliest

uses of the SAC(A). During the Marine operations in Nicaragua, aircraft were employed to escort and observe the progress of the Marines through the jungle terrain. The SAC(A) provided warning to the Marines when they were approaching likely ambush sites, and kept them informed as to their position in relation to other friendly units. To accomplish observation, a SAC(A) must be able to remain overhead the ground forces for a long enough time to gain situational awareness of the disposition of friendly ground units, and become familiar with the surrounding terrain. The SAC(A) must have excellent visibility, and be able to operate in poor weather and at night. To be effective both during the day and at night, the SAC(A) require binoculars, night optics, flares, or infrared to maintain observation of the battlefield.

Radio Relay

The range of the radios and the terrain in which maneuver forces are operating often limit communications between ground stations. An airborne platform has the potential advantage of having direct "line of sight" with numerous positions on the ground. Since the nature of radio communications is dependent on radio waves traveling from one transmitter/receiver to another, direct line of sight between radios is optimal. In some terrain, such as the mountainous battlefields of Korea, and the jungles of Vietnam, airborne radio relay was absolutely essential (Lester 1997, 57). SAC(A) aircraft have been used for passing information between ground units in every war that has employed airpower. To accomplish radio relay, the SAC(A) must have a robust communication suite with at least two radios. Typically, aircraft must remain in contact with some type of air control agency on one radio, which indicates a minimum of two radios are necessary to provide radio relay services. The radios should cover the full spectrum of frequencies that the SAC(A) would be expected to cover in the course of his potential mission profiles.

Reconnaissance in Direct Support of Maneuver Forces

The SAC(A) is often assigned in direct support of ground forces as in the case of the T-6 Mosquito in the Korean War. The presence of the SAC(A) extends the range at which the maneuver commander can detect and identify enemy forces. This provides the ground commander with a distinct advantage if the enemy has been denied the use of his aircraft in this way due to friendly air superiority. By performing aerial reconnaissance, the SAC(A) is able to assist the ground commander in his effort to maneuver his forces to tactical advantage, and bring firepower to bear on the enemy. To accomplish aerial reconnaissance the SAC(A) must have the endurance to remain over head to detect the enemy when he is out in the open, or when he is well hidden. OV-10 aircraft in Vietnam flew below 1,000 feet with binoculars to locate North Vietnamese Army and Viet Cong forces under the cover of the jungle canopy (Yarborough 1990, 84). SAC(A) aircraft used for aerial reconnaissance must also be able to perform at night and in poor weather. Sensors, such as infrared, radar, cameras, binoculars, and night optics, enhance the SAC(A)'s ability as reconnaissance asset.

Reconnaissance in Support of Deep Operations

SAC(A) aircraft have been used to locate, identify, and report on targets deep into enemy territory. The Air Force used pathfinder jet strike aircraft in Korea and Fast-FAC F-100F fighters in Vietnam in this role (Lester 1997, 72, 174). The purpose of these deep reconnaissance missions was to provide intelligence on the status of either predetermined targets or to locate targets of opportunity. Higher level commanders used this intelligence to aid in the destruction of interdiction and strategic targets. To accomplish deep reconnaissance the SAC(A) has to be survivable due to higher threat levels that tend to exist the farther he penetrates enemy territory. Fast jet aircraft are best suited for these missions due to their high speed. The SAC(A) also benefits from being armed in this role to both defend himself and eliminate potential threat systems for follow-on strike aircraft. In Desert Storm F/A-18D Fast-FAC aircraft flew with an

armed escort to provide protection for the SAC(A) in the conduct of his mission, and to eliminate surface to air threats (Stout 1997, 114). Sensors that provide stand off from the threat, such as binoculars, infrared, radar, and cameras will assist the SAC(A) in this role.

Command and Control

The benefit of good communications and excellent observation due to the airborne realm of the SAC(A) make him an ideal platform from which to conduct command and control of air and ground forces. OV-10 aircraft in Desert Storm that conducted airborne tactical air coordination provided twenty-four hour service to the Marine Air Ground Task Force (Culbert and Gamboa 1991, 98). In this instance, the OV-10 had the responsibility to ensure that close air support was directed to the areas of the battlefield that were most in need of support. The SAC(A) can also be used in the command and control role to direct the employment of maneuver forces as in Vietnam. OV-10 and UH-1 helicopter SAC(A) aircraft were used in this manner to direct the movement of ground forces in Vietnam (Harrison 1989, 24). To perform as a command and control platform the SAC(A) must have long endurance over the battle field to ensure continuity and develop broad situational awareness. The SAC(A) must also have a robust and versatile communication suite, and be able to manage lots of information. Multi-place SAC(A) aircraft allow crews to share the high workload of command and control missions.

Terminal Control of Indirect Fires

SAC(A) aircraft have been particularly effective at coordinating and controlling the employment of indirect fire systems such as artillery, mortars, and naval gunfire. In World War I, both sides utilized spotter planes to direct artillery on to enemy trench formations (Lester 1997, 3). Spotter planes were used during World War II to direct the fires of naval guns during the war in the Pacific (Cooling 1990, 316). SAC(A) aircraft are particularly adept in this role due to the nature of indirect fire. Artillery and naval gunfire tends to have a large dispersion of projectile impacts along the gun to target line. For spotters on the ground attempting to adjust fires, it is

difficult to determine how far the projectile missed the target along this axis since they must view the target and the impact in the same horizontal plane. Airborne spotters are obviously not in plane with the target and the projectile impact, so effective adjustment is considerably easier. To be effective at the terminal control of indirect fires, the SAC(A) must have the endurance to remain overhead during the characteristically slow pace of the delivery systems. To conduct indirect fire adjustment from tactically safe altitudes and at night, binoculars, night optics, flares, or infrared may be required.

Terminal Control of Close Air Support--FAC(A)

Airborne forward air control or FAC(A) has been a hallmark of SAC(A) missions since World War II. The FAC(A) extends the range that the maneuver forces can detect and bring fires to bear on the enemy. The FAC(A) must have acute situational awareness of the disposition of friendly forces to prevent fratricide by close air support aircraft. The FAC(A) must maintain visual contact with the forward line of troops (FLOT) and direct the delivery of ordnance by CAS aircraft on the enemy in very close proximity to friendly forces. To perform airborne forward air control, the SAC(A) must be survivable near the FLOT. He must be able to mark enemy targets by some means to distinguish friend from foe for the CAS aircraft. This is traditionally done with unguided white phosphorous (WP) rockets, but may also employ the use of lasers. Endurance over the battlefield is necessary to allow time for the SAC(A) to determine the disposition of friendly and enemy forces. Sensors such as infrared, radar, binoculars, night optics, and precise navigation and targeting equipment enhance the ability of the SAC(A) in this role.

Terminal Control of Deep Air Support--SCAR

This mission has been called by many names, and can overlap deep aerial reconnaissance. In Korea, it was called pathfinder. In Vietnam it was referred to as Fast-FAC. In Desert Storm the Air Force called the mission Hunter-Killer or Pointer FAC, while the Marine Corps called it SCAR (strike coordination and reconnaissance). In all cases, the SAC(A) had to

be fast and survivable to work deep into enemy held territory for the purpose of detecting and targeting enemy forces. Since these deep targets are not near friendly forces, the risk of fratricide is minimal. This provides a very permissive environment for the SAC(A) to engage the enemy rapidly, once acquired. The survivability of the SAC(A) in this role is enhanced by stand-off target detection sensors such as binoculars, night optics, infrared, and radar. As with forward air control, the SAC(A) must be able to mark enemy targets by some means to identify them for the strike aircraft. This is traditionally done with unguided white phosphorous (WP) rockets, but may also employ the use of lasers.

Mission Requirements: SAC(A) Aircraft Characteristics

The ability of the SAC(A) to execute the eight mission essential tasks listed above is directly affected by the characteristics and capabilities of the aircraft tasked to perform the supporting arms coordination role. There are five characteristics that are critical to success of the SAC(A) platform. The analysis of each of the four aircraft chosen for the study will include an evaluation of the survivability, endurance, communications, and aircraft systems of each platform.

Survivability

The survivability of an aircraft in performing in the SAC(A) role is defined by the threat systems that occur in the close and deep air support environments. For CAS, this area is generally known as the FLOT (forward line of troops). The threat systems near the FLOT are doctrinally considered to consist of small arms fire from the surface combatants, light to medium anti-aircraft artillery (AAA), man-portable short-range surface to air missiles, and short to medium range vehicle mounted missile systems. In the deep air support area, the threat may consist of integrated air defense systems (IADS). IADS consist of tactical and strategic air defense systems controlled by an air defense network. The weather and the terrain also play a large part in defining the threat to SAC(A) aircraft. The aircraft is not vulnerable to small arms

fire and light AAA at medium altitude, but if the weather forces the SAC(A) down to low altitude to perform his mission, the risk grows considerably. Likewise, if the terrain is such that it is difficult to locate targets like in a jungle or wooded area, the SAC(A) may have to descend to low altitude to be effective (Yarborough 1990, 236). Night tactics generally negate the effectiveness of many infrared guided weapons such as hand held surface to air missiles.

Jet strike fighters are generally considered to be the most survivable aircraft due to their high speed and maneuverability. They can enter and exit the threat area quickly, and climb rapidly out of harms way. A slower aircraft may also be survivable in certain scenarios, however, such as in jungle or wooded terrain where the enemy's view to the sky is obscured by vegetation. Other physical characteristics also contribute to survivability such as having more than one engine, armor plating, redundant flight control systems, and defensive countermeasures. These countermeasures may consist of low observable paint schemes, radar warning receivers, radar jammers, flares to decoy infrared missiles, and chaff to decoy radar guided missiles.

A SAC(A) platform that has the ability to defend itself from both surface to air and air-to-air threats will certainly be more survivable than one that cannot. An armed SAC(A) aircraft not only has the ability to protect itself, but can provide on the spot support to ground forces until more heavily armed close air support aircraft arrive (Harrison 1989, 52, 202, 280).

Endurance

The SAC(A) must be able to remain over head the supported ground unit long enough to gain situational awareness of the tactical scenario, and render assistance when required. Land warfare occurs at a much slower pace than air warfare, which dictates that the SAC(A) must have good endurance or "time on station." Close air support aircraft typically arrive with a heavy load of ordnance and a relatively short window of opportunity in which to deliver it on target. Heavily loaded strike aircraft are generally not suited to loiter for long periods as the tactical situation develops on the ground.

Ideally, the SAC(A) will be available at the critical point in time when the friendly forces are approaching contact with the enemy. Good planning based on the available intelligence should help to ensure that the SAC(A) is on station when needed. Warfare is by nature chaotic and unpredictable, so a SAC(A) platform that can cover a long period of support is more likely to be available at the critical juncture. Endurance for the SAC(A) must also include a certain amount of time allotted for one aircraft to perform a battle hand over to his relief. Based on previous combat experience, this should be ten minutes, at a minimum (Yarborough 1990, 43).

Communications

The SAC(A) must be able to communicate with the supported ground forces, otherwise he cannot accomplish the detailed coordination required in the close air support environment. The aircraft's communication system must not only be compatible with the ground forces, but also offer flexibility and redundancy to ensure that there are no breaks in the coordination process. Military aircraft typically are required to monitor both air-to-air and air-to-ground radio nets, which dictates that the SAC(A) must have at least two radios. The doctrinal close air support command and control system also defines the type of communications hardware that the SAC(A) must have on board. The SAC(A) may be required to communicate on a broad spectrum of the frequency band to include high frequency (HF) for long range, very high frequency (VHF) for medium range, and ultra high frequency (UHF) for short range.

Aircraft Systems

Aircraft can carry numerous systems to enhance their effectiveness. Accurate navigation equipment is perhaps the most basic necessity. Tactical air navigation (TACAN) and global positioning systems (GPS) are external navigation sources. Onboard systems like inertial navigation systems (INS) and Doppler navigation offer a self contained capability. Although nothing is more reliable than the aircrew's ability to navigate with their own eyes and a map, electronic navigation systems are critical assets on the modern battlefield.

Target acquisition systems are essential to the SAC(A) in the course of his duties. The naked eye will always be the primary sensor in the cockpit. The aircrew must be able to observe and scrutinize the terrain and ground forces below without making themselves vulnerable to ground fire. Stand-off observation devices, such as hand-held binoculars, can extend the stand-off range that the SAC(A) can perform his duties. There are limits to the use of unstabilized optical devices since the motion of the aircraft affects the steadiness of the image as seen by the aircrew. The field of view cannot be too narrow, nor can the magnification be too great. Studies have shown that a 50-millimeter lens offers the minimum field of view and a magnification factor of eight (8x) or less is optimal for hand-held optics used in an aircraft (MAWTS 1 1994, 91).

The SAC(A) must not be hindered by the night environment. Night vision devices that magnify ambient moon and starlight are very effective aids to aircrew. However, these devices can only be used in aircraft that have compatible cockpit lighting. Infrared sensors are capable of detecting heat sources such as main battle tanks and trucks carrying logistics during both day and night operations. Certain radar systems have the ability to pick out moving vehicles in all weather conditions. Laser technology offers two potential capabilities to the SAC(A). First, a laser-equipped aircraft can be used to designate ground targets for precision attack by laser-guided bombs and missiles. Second, a laser spot tracker (LST) allows an aircraft to receive precise targeting data from ground or airborne laser designators. Aircraft that are equipped with these modern systems provide outstanding capabilities to SAC(A) aircrew which enable them to perform in the widest range of tactical scenarios.

Aircraft Characteristics Evaluation Criteria

Based on the discussion above, each aircraft will be evaluated against the following criteria in the four aircraft characteristic categories. Although certain technologies may not have existed during the reign of the older aircraft, the criteria will provide an evaluation of aircraft potential on the modern battlefield.

Survivability:

Speed; Multiple Engines; Armament; Armor; Radar Warning Receiver;
Redundant Flight Control Systems; Defensive Countermeasures; Jammer

Endurance:

Un-refueled loiter time at 150 nautical miles from departure base.

Communications:

Number of Radios; Flexibility; Frequency Range (HF/VHF/UHF);
Secure Voice Transmission Capability

Aircraft Systems:

Precision Navigation; Infrared; Night Vision Devices; Radar;
Laser Designator; Laser Spot Tracker; Stand Off Observation Devices

Comparison of Past and Present Airborne Supporting Arms Coordination
Platforms to the Mission Requirements

This step in the analysis will focus on five sample aircraft that have performed as supporting arms coordination platforms in the last three major wars: Korea, Vietnam, and Desert Storm in Southwest Asia. The five aircraft chosen cover a wide range of technology and capability beginning with a World War II vintage aircraft, and ending with a modern digital jet strike fighter. First, the specifications of each aircraft is listed to provide a baseline understanding of the capabilities of the airframes. Each of the four aircraft is then evaluated against the eight mission essential tasks and four aircraft characteristics determined in the previous step. This process will determine how SAC(A) aircraft have capitalized on their strengths and overcome their weaknesses in the performance of SAC(A) missions under combat conditions. The resultant data suggest answers to the primary research question of how to best employ the F/A-18D. The five aircraft chosen for evaluation are the:

1. T-6 Mosquito (Figure 1, Table 1)
2. OV-10 Bronco (Figure 2, Table 2)
3. OA-10 Thunderbolt II (Figure 3, Table 3)
4. AH-1W Super Cobra (Figure 4, Table 4)
5. F/A-18D Hornet (Figure 5, Table 5).

T-6 Mosquito

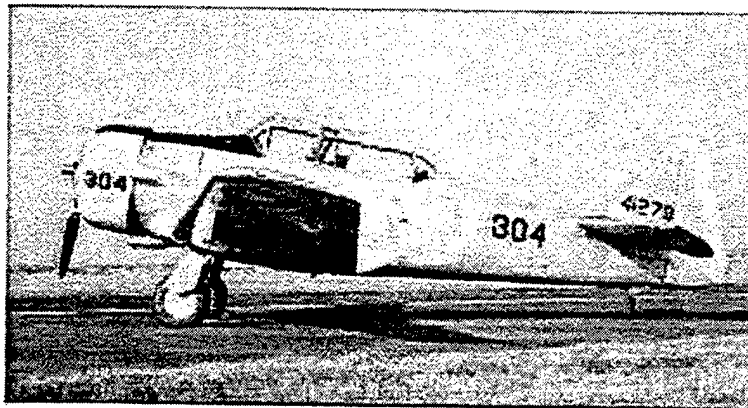


Figure 1. T-6 Mosquito (*Jane's* 1933, 135)

Primary Function

The T-6 was an observation, visual reconnaissance, radio relay, and forward air control platform.

Features

The Mosquito is a low wing, single engine monoplane of all metal construction and conventional landing gear. It has a low stall speed and excellent short field performance.

Background

The Mosquito was a tactical adaptation of the World War II vintage T-6 Texan primary trainer aircraft brought into service by the Air Force during the Korean War in response to need for a better forward area ground liaison aircraft to replace the less capable L-5 spotter plane.

Table 1. T-6 Specifications (*Jane's* 1933, 135)

Manufacturer:	North American	Max Speed @ S/L:	210 MPH
Introduction Date:	1 939	Cruising Speed:	170 MPH
Model:	T-6G	Max Climb Rate:	N/A
Crew:	Pilot + Observer	Max Ceiling:	21,500 feet
Dimensions:	Length – 29 feet Wingspan – 42 feet	Max Range:	1000 miles
Max T/O Weight:	5250 pounds	Combat Radius w/ max weapons load: (no loiter) 330 miles (est.)	
Power Plant:	550 HP P&W R-1340 air cooled radial 2-bladed constant speed propeller		
<u>Aircraft Systems</u>		<u>Armament</u>	
Navigation:	Visual / Compass	Fixed:	None
Communications:	1 VHF 8 channel radio	Disposable:	2.25 inch marking rockets
Recon sensors:	Hand held cameras		

T-6: Evaluation of the Eight Mission Essential Tasks

Observation

The two-seat Mosquito was crewed by an Air Force pilot and a US Army observer in the back seat. This crew arrangement was a direct result of the ground commander's need to add a ground soldier's view to the aerial control functions. Although the primary mission of the T-6 was to control air strikes, its incredibly long endurance of over three hours enabled the crew to perform a myriad of additional tasks. The Army observer was able to survey the terrain and the disposition of friendly forces, which gave a broad perspective of the battlefield. He was able to communicate this perspective to the Army commanders on the ground. The Army observer could provide tactically relevant information that may have been overlooked by the Air Force pilot due to his lack of familiarity with ground combat operations. The aircraft itself was an average observation platform. The low wing design blocked downward visibility, which made it inferior in this regard to the L-5 high wing, spotter aircraft that the T-6 replaced. Better speed and maneuverability, however, allowed the T-6 to survey a larger area, and get in and out of the tight mountain passes that dominated the Korean landscape (Lester 1997, 39).

Radio Relay

The T-6 was tasked to perform a radio relay mission referred to as "Mosquito Mellow," due to the long range from the front lines to the Tactical Air Control Center (TACC) at Taegu (Lester 1997, 52). The mountainous terrain of Korea also affected communications. Direct line of sight communications had to be established between the TACC and the front, so a T-6 would orbit at an intermediate point to relay messages. This was critical to the success of the tactical air control system, and the rapid responsiveness of close air support to the forward lines (Lester 1991, 39). As a radio relay platform, the T-6 had the same advantage that any fixed-wing aircraft has. It could fly high where its radio could achieve line of sight with the two ground stations. The aircraft was limited, however, by having only a single VHF radio.

Reconnaissance in Direct Support of Ground Forces

The stated role of the Mosquito at the beginning of its use as a SAC(A) aircraft during the Korean War was "to make flights over the front lines, locate targets, and direct fighter attacks" (Lester 1997, 45). This initial mission statement expanded throughout the war to include what was termed visual reconnaissance. The T-6 was tasked to search the area in the vicinity of the forward line of troops to report on enemy activity that could immediately affect friendly forces. The area of concern was generally from the front lines back to the enemy's artillery. Anything further than that was considered deep reconnaissance. The long endurance of the T-6 allowed it provide continuous coverage for large friendly movements such as convoys, and eventually lead to a policy of T-6 TAC-As being airborne from sunup to sundown. The aircraft was well suited to the task given that the primary surface to air threat near the front at the time was enemy small arms and machinegun fire. These threats were generally ineffective above 1,500 feet, which still provided a good view of the ground to locate the enemy (Harrison 1989,82). Binoculars used by the Army observer aided in the reconnaissance effort of the Mosquito. The T-6 was virtually

ineffective at night, however, since the technology of the time offered no night sensors, such as infrared or night optical devices.

Reconnaissance in Support of Deep Operations

The success of the T-6 in performing reconnaissance for ground forces led to the tasking to perform "area reconnaissance" missions. By rule, the T-6 was not authorized to perform deep penetration missions since it was not considered to be survivable enough. Area reconnaissance allowed the T-6 to reconnoiter the area directly behind the enemy's forward lines. This was not to the liking of the ground commanders since they feared that the T-6 might be unavailable if immediate close air support was needed. As a result, area reconnaissance had to be under the operational control of the supported ground commander. Consequently, the enemy's logistics were relatively unhampered except in the immediate vicinity of the front for most of the war. T-6 crews carried hand-held cameras for a limited photo-reconnaissance capability, but results were disappointing. The vibration of the aircraft produced blurred images (Lester 1997, 50).

Command and Control

The Mosquito Mellow radio relay missions mentioned previously aided in the command and control effort to ensure that close air support was responsive. Mosquito aircraft were referred to as airborne tactical air coordinators or TAC-As. These missions were the first doctrinal uses of aircraft in the command and control role of coordinating the efforts of strike aircraft in support of ground operations. The TAC(A) mission is still a part of modern close air support doctrine. The Mosquito was well suited for the command and control role, primarily due to its long endurance. For these missions the T-6 could remain on station for over four hours. Although limited by having a single radio, the Mosquito's ability to stay aloft for so long made up for this shortcoming.

Terminal Control of Indirect Fires

The Mosquito was not used extensively as an indirect fire spotter platform. The L-5 flown by Army pilots performed this duty. The L-5 was slow and had a more limited four channel radio. This is why the T-6 was chosen as a forward air control platform. The L-5 did, however, meet the requirements for an artillery spotter. The two aircraft complemented each other well, sharing the airborne supporting arms coordination tasks (Lester 1997, 34). Presumably, the T-6 could have made an effective indirect fire platform due its endurance and the fact that an Army observer was part of the crew.

Terminal Control of Close Air Support--FAC(A)

Forward air control was the forte of the T-6 Mosquito during the Korean War. It was brought into the war primarily for this purpose. The technique of having a slower plane spot a target and call in a jet to attack it was born in Korea during July of 1950. Lieutenant Colonel Stanley P. Latiolas, 5th Air Force operations officer, conceived the idea when North Korean forces were battering small American and Korean Army units. He sent two of his lieutenants up in L-17 light aircraft to relieve the pressure on the ground forces by controlling close air support onto the North Korean forces. The two officers controlled ten flights of F-80 Shooting Stars that day, which was called "the best day in 5th Air Force history" (Lester 1997, 34). The very next day a fledgling unit of more capable T-6 aircraft was organized to serve as permanent forward air controllers. Their effectiveness was so impressive that ground commanders soon took a proprietary interest in the Mosquitoes and were reluctant to let the controllers out of their sight. By August of 1950, barely one month after their introduction into the war, it became emphatic that Mosquitoes were assigned to each division. For the remainder of the war, no ground operation was planned without including airborne forward air controllers. The T-6 TAC-As had become associated with responsive and effective close air support. The restrictive terrain affected communications as well as the observation and target detection capability of the ground FACs.

The T-6 airborne forward air controllers provided the vast majority of the terminal control of close air support. The T-6 had 2.25-inch white phosphorous rockets to mark targets with, and a good radio to talk to the strike aircraft. These assets and the combined Air Force and Army crew made the Mosquito an outstanding forward air control platform.

Terminal Control of Deep Air Support--SCAR

The T-6 was not well suited to make deep penetrations into enemy territory. Its 200 miles per hour speed and good maneuverability were perfectly matched to its duties near the front lines. It had just enough speed to dart back and forth across the forward lines with minimal exposure to enemy ground fire. Operational necessity caused some Mosquito crews to press twenty-five miles deep at times to locate enemy troop formations. They achieved outstanding success during these risky missions, sometimes controlling as many as sixteen strike sorties at a stretch causing hundreds of enemy casualties (Lester 1997, 68). They usually suffered severe battle damage on these excursions, however, and the Air Force did not encourage the use of the T-6 in this manner. The need for control of deep air strikes led to the pathfinder missions conducted by jet aircraft as discussed previously in the historical study.

T-6: Evaluation of the Four Aircraft Characteristics

Survivability

The T-6 Mosquito was a single engine aircraft with a maximum speed of around 200-miles per hour. The engine was an air-cooled radial piston power plant of 550-horsepower. Despite having just one motor, the Mosquito's radial engine could sustain significant damage from small arms fire. Such engines could lose whole pistons and still maintain adequate power to keep the aircraft flying. Water-cooled engines could be disabled with one well placed shot to a radiator or waterline. The threat in Korea near the front was primarily small arms. This made the T-6 survivable near the forward line of troops with good tactical flying by the pilot. With no

armor, the pilots had to be careful to limit their exposure to ground fire by darting back and forth over enemy locations.

Many T-6 crews pleaded that armament be added to the aircraft in the form of two .50-caliber machine guns. The T-6 could only carry 2.25-inch white phosphorous rockets for marking targets. Without armament, the T-6 was at a disadvantage, since it did not have the ability to attack surface to air threat systems or perform limited suppressive fires in support of ground forces before CAS aircraft came on station. Some crews actually used the marking rockets to attack enemy forces in extremis situations with good effect. The leadership did not take heed, and the Mosquitoes were not upgraded with the weapons for fear that FAC crews would lose sight of their intended role and put themselves at risk unnecessarily.

Endurance

The T-6 Mosquito had outstanding endurance over the battlefield. This was perhaps its best attribute. It could loiter for more than two hours at a range of 150 miles from its departure base. Despite its limitations of basically being an unarmed training aircraft, it could remain overhead the maneuver forces for so long that it could provide invaluable service merely by its consistent presence. For radio relay and command and control missions, the T-6 remained on station for four hours. For forward air control and visual reconnaissance missions, it usually worked for three hours (Lester 1997 39).

Communications

The T-6 had one eight channel VHF radio. This was not ideal since the crew had to juggle back and forth among the different ground and air channels to get the job done. Because of its outstanding endurance, the T-6 had plenty of time to make all of the necessary communications happen. Despite the single radio limitation, the T-6 was the best option available because of the mountainous terrain and the limitations of the large vehicle mounted ground radios in service at the time.

Aircraft Systems

The T-6 had no advanced aircraft systems. The lack of navigational aids in Korea during the 1950's limited the Mosquitoes to map and compass navigation. This made them much less effective in poor weather, and at night. Crews used hand-held binoculars and cameras with limited success due to the relatively high vibration level of the radial-piston engine.

OV-10D Bronco

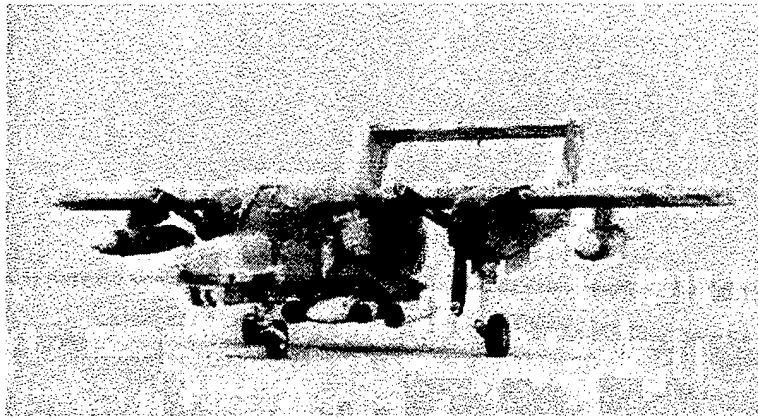


Figure 2. OV-10 Bronco (*Jane's* 1992, 355)

Primary Function

The Bronco was an observation, radio relay, helicopter escort, indirect fire control, utility, parachute drop, light attack, visual and sensor reconnaissance, tactical air coordination, and forward air control platform.

Features

The OV-10 was a high wing, twin-tail, twin-engine turbo-prop of all metal construction. It had a two-seat tandem cockpit with excellent visibility (10 degree AOB enables crew to see directly below the aircraft). It had two under fuselage sponsons for external stores. The internal cargo bay of 110 cubic feet had room for 3,200: pounds of cargo or six infantrymen; five

paratroopers; one medic and two litters or four walking wounded. The Bronco has low stall speed, excellent short field and rough field performance, and long battlefield endurance.

Background

A 1959 study by the Marine Corps established the need for a light Marine attack aircraft that could operate from unprepared forward airfields to conduct light attack and observation missions, as well as helicopter escort. Out of this need grew a joint Marine, Navy, and Air Force requirement for a Light Armed Reconnaissance Aircraft (LARA).

Table 2. OV-10 Specifications (*Jane's* 1992, 335)

Manufacturer:	North American	Max Speed @ S/L:	250 knots
Introduction Date:	1968	Cruising Speed:	180 knots
Model:	OV-10D+	Max Climb Rate:	3000 fpm
Crew:	Pilot + Observer	Max Ceiling:	30,000 feet
Dimensions:	Length – 44 feet Wingspan – 40 feet	Max Range:	1380 NM
Max T/O Weight:	15,000 pounds	Combat Radius w/ max weapons load: (no loiter) 200 NM	
Power Plant: 2 x 1040 HP Garret Turbo-props 2 x 3-bladed constant speed propellers			
<u>Aircraft Systems</u>		<u>Armament</u>	
Navigation:	TACAN ADF GPS (hand held)	Fixed:	4 x 7.62mm machine guns 2 per sponson 500 rounds each
Communications:		Disposable:	
Cockpit Management System (CMS) with 3 x multi-band FM / VHF / UHF radios 1 x HF radio		Up to 3,600 pounds of ordnance on 7 hard points: 1 fuselage (1200 lbs.); 4 sponson (600 lbs. each); 2 wing (600 lbs. each). Weapons included: Free fall 500 & 1000 pound bombs, cluster bombs, fire bombs, 2.75 & 5 inch rockets, illumination flares, 7.62 & 20 mm gun pods, AIM-9 Sidewinder air-to-air missiles, and Hellfire air-to-ground missiles	
Night Vision Devices:	N/A		
Laser Spot Tracker:	N/A		
Radar:	N/A		
Infrared:			
One Texas Instruments infrared Night Observation System (NOS) with a Laser Range finder / Designator and automatic video tracker			
Reconnaissance sensors:	Hand held cameras		

OV-10 Bronco: Evaluation of the Eight Mission Essential Tasks

Observation

The OV-10 Bronco was crewed by a pilot and an aerial observer much like the T-6 Mosquito. The Marine observers were ground combat arms officers that served three-year tours with Bronco squadrons. In Air Force service a single pilot flew the OV-10 most often. In support of Special Forces operations, however, an Army noncommissioned officer was carried on many missions to enhance coordination with the dispersed ground teams (Yarborough 1990, 108). The Bronco was perhaps the best observation platform of the aircraft selected for this study. The aircraft had a high wing that was attached to the fuselage aft of the back seat crewmember. This gave both crewmen an unobstructed view of the ground below. The design of the canopy was convex and curved out beyond the lateral limits of the forward fuselage. This allowed the crew to look directly below the aircraft with a very minor roll of 10 degrees to the left or right. The wide canopy also allowed the use of optical devices such as binoculars, telescopes, and night optics.

Radio Relay

The OV-10 was an outstanding communications platform with four radios covering the UHF, VHF, HF, and FM bands. This allowed Bronco crews operating near the forward lines to coordinate with support agencies at great distances. In Vietnam, infantry units often operated in dense jungle and in restricted terrain that were not conducive to good radio communications with fire support agencies. Helicopters often supported ground operations, but by their nature, flew at low altitude. They were not able to communicate at the ranges that a higher flying fixed-wing aircraft could achieve. OV-10s in Vietnam were able to achieve line of sight communications with several ground stations, and could thus maintain the critical links.

Reconnaissance in Direct Support of Ground Forces

The OV-10 was particularly adept at aerial reconnaissance in support of ground forces. This mission was the *raison d'être* for the original requirement for the Bronco. Due to the terrain in Vietnam, ground forces were unable to maintain observation very far around their positions. The Broncos would fly overhead friendly formations on the ground for hours providing look out and early warning of enemy concentrations in the vicinity (Harrison 1989, 78). In Desert Storm, infrared equipped OV-10s flying near the front could identify Iraqi vehicles at two or three times the range that ground forces could. During both wars the OV-10s maintained continuous contact with the supported ground forces to keep them apprised of enemy actions in their area. As aerial reconnaissance assets Broncos would respond to requests for information on specific areas of interest designated by ground commanders, as well as maintain general reconnaissance over a given area or friendly ground unit. The OV-10 was effective both during the day and at night as an aerial reconnaissance platform. Binoculars were always carried during the day. The Night Observation System (NOS), which included a forward looking infrared and laser designator was incorporated on the OV-10D models in 1985 in time for Desert Storm.

Reconnaissance in Support of Deep Operations

Arc Light bombing missions conducted by B-52s in Vietnam required battle damage assessment to determine their effectiveness. The OV-10s were called up numerous times to fly over the impact zone to reconnoiter for enemy casualties. The North Vietnamese were quick to repair or hide any damage, so these flights had to go into the zones very soon after the attack (Harrison 1989, 234). The Broncos would use standard area reconnaissance techniques to survey the area. The flights were always conducted during the day for maximum observation of the target area. Operating far from the front was not the most survivable tactic for the slow, low flying Bronco. During Desert Storm OV-10s operated well forward of the forward line of troops attacking enemy artillery positions. One aircraft was shot down on the second day of the war

(Mesko 1995, 42). Faster and more survivable jet aircraft like the pathfinder operations of the Korean War are best able to conduct the aerial reconnaissance requirement overhead enemy occupied territory. The OV-10 was not well suited for deep reconnaissance missions.

Command and Control

The OV-10 TAC(A)s assisted in the command and control of air support for ground forces in both Vietnam and Desert Storm. The Bronco played a significant role in rescue operations of down pilots in South East Asia. OV-10s would respond to rescue situations by proceeding to the area, setting up an orbit at altitude, and taking over control of the operation as the "on scene" commander. Because of its long endurance and outstanding communications suite, it was perfectly suited to carry out this mission. The Bronco would establish communication with the downed crewmen and coordinate the efforts of the rescue package, which usually consisted of rescue helicopters and ground attack aircraft for security.

The OV-10 was also used to coordinate the flow of close air support aircraft into hot areas of the battlefield in both Vietnam and Desert Storm. In South West Asia, OV-10s operating near the front lines of Marine Forces had the command authority to divert interdiction sorties to provide close air support to requesting units. This procedure was particularly effective because of the "Push CAS" concept employed during that conflict. Push CAS tactics involved launching strike sorties at regular time intervals every ten to thirty minutes to prosecute interdiction attacks far beyond the forward line of troops. These flights were scheduled in lieu of a large number of sorties designated specifically for CAS. If a request for CAS occurred, then aircraft would be diverted from their interdiction strike to service the CAS mission. This process ensured that strike aircraft were available at all times and could respond quickly. The OV-10 acting as an airborne tactical air coordinator or TAC(A) would maintain situational awareness near the front lines and coordinate the link up between the diverted strike aircraft and the ground forces in

contact with the enemy. The OV-10 could remain on station for over four hours as a command and control platform.

Modern doctrine provides for an air request net to be used as the primary means of requesting close air support by ground forces. This is a long-range HF (high frequency) radio net due to the typical distances that exist between the front lines and the close air support control agencies. In the Marines, this is called the Tactical Air Request / Helicopter Request Net (TAR/HR). Depending on the size of the theater, there may be several users all trying to get through on that frequency. In a generic Marine division there are nine infantry battalions in three regiments, one tank battalion, and one light armored reconnaissance battalion. Each of these eleven battalions has two forward air controllers and one air officer assigned for a minimum of thirty-three air liaison officers that are all potential users of the TAR/HR net in one division. The Marine Corps deployed two full divisions to Desert Storm plus many attached units such as the armored Tiger Brigade from the Army, and the Arab Coalition Division. Both of those units had Marine Air and Naval Gunfire Liaison Company (ANGLICO) teams assigned. There were nearly one hundred close air support liaison officers in the Marine Air Command and Control System (MACCS) that were all potential users of the HF TAR/HR Net. Once the fighting started, the system was overwhelmed. The OV-10s, which were able to monitor the HF TAR/HR Net would intercept the transmissions of frantic forward air controllers trying to get their requests for air support through the communications quagmire. After making contact with a FAC, the Bronco would switch the conversation to an open UHF frequency to copy the air request. The OV-10 TAC(A) would then forward the request to the air control agencies for approval or fill the request with available assets. In many cases, such as the surprise attack by the Iraqis on Khafji, the OV-10 was the critical link in getting air support to the front lines.

The OV-10 was also employed during Desert Storm as TAC(A) platform to coordinate artillery counter-battery fire. These missions were called "quick fire," and required the Bronco to

remain on station for long periods to be available when Iraqi artillery fire was detected. Working closely with the targeting processing centers, the TAC(A) received the mission and coordinated the destruction of enemy artillery with Marine artillery or CAS aircraft (Culbert and Gamboa 1991, 98).

Terminal Control of Indirect Fires

The OV-10 was designed to perform all of the roles that might be required of an observation, forward air control or spotter type aircraft. It was used in both Vietnam and South West Asia to control and adjust the fires of artillery and naval gunfire. The outstanding observation and communication capability of the Bronco made it a perfect indirect fire controller. The tempo of indirect fire is generally slow and may take several rounds of adjustment to get the fires on target. The long loiter time of the OV-10 continued to be a significant advantage for conducting this mission as well.

Terminal Control of Close Air Support--FAC(A)

Forward air control was the primary mission of the OV-10 throughout its career. Close air support requires detailed integration between air and ground forces. All of the characteristics of the OV-10 contributed to its ability to operate as a FAC(A). Long endurance allowed crews to gain a full understanding of the disposition of friendly ground forces. Good visibility from the cockpit allowed easy visual acquisition of ground targets and strike aircraft. Slow speed was an advantage in situations where the fighting took place over restricted terrain like in Vietnam. Fast jets were unable to discern hard to find targets that were hiding under the tree lines. FAC(A)s controlled the majority of air strikes in Vietnam (Yarborough 1990, 44). The OV-10 could carry 5-inch Zuni and 2.75-inch white phosphorous rockets to mark targets from long and close range. In South West Asia, the OV-10D model had a laser designator for precision control of strikes in very close proximity of friendly forces (Mesko 1995, 19).

Terminal Control of Deep Air Support--SCAR

The OV-10 was not suited for operating deep inside enemy territory due to its lack of survivability against high threat surface to air systems. The OV-10 was designed to operate in a low threat environment defined by small arms fire and light antiaircraft weapon systems. Deep operations are normally conducted against the enemy's strategic centers, which are normally near large population areas, industrial sites, and infrastructure, which are usually heavily defended. To attack deep targets may involve going against an enemy's integrated air defense systems, which include radar guided gun and missile systems. The OV-10 was generally not survivable in this environment.

OV-10: Evaluation of the Four Aircraft Characteristics

Survivability

The OV-10 was slow by modern tactical aircraft standards. Its maximum speed with a weapons load was around 240 knots. The speed of jet aircraft, normally above 400 knots, offers a significant advantage in survivability against threat systems found near the forward lines where SAC(A) aircraft operate. The Bronco had the safety of two engines, two electrical generators, and redundant hydraulic systems. The twin boom design with two rudders allowed the aircraft to keep flying if a single aerodynamic surface was hit. Three hundred pounds of armor protected the crew and critical components. Two independent fire warning systems and self-sealing fuel tanks prevented catastrophic fire damage. For further protection the OV-10D model Bronco had a radar warning receiver, an infrared missile jammer, and chaff / flare dispensers.

The OV-10 had an outstanding array of weapons in its arsenal. Four 7.62-millimeter machine guns with 2,000 rounds were carried in the sponsons attached to the lower fuselage. These were employed with great success in Vietnam to provide immediate suppression of enemy forces before CAS aircraft could arrive on the scene. As mentioned previously, pilots of the T-6 Mosquito had requested similar armament during the Korean War for the same purpose but were

ignored. The Bronco could also carry 5-inch and 2.75-inch explosive rockets, iron bombs, 7.62 and 20-millimeter gun pods, Hellfire laser guided missiles, and Sidewinder air-to-air missiles. The OV-10 was able to attack enemy weapon systems with its own organic weapons when it was threatened. It was the first SAC(A) aircraft that had this capability.

In Vietnam, the OV-10 was very survivable due to the nature of the environment and its twin-engine redundancy. The terrain of Vietnam was, in many areas, heavily overgrown with dense jungles. Surface to air threats normally consisted of, small arms, heavy caliber machine guns, and anti-aircraft guns. These systems were normally guided by the naked eyes of the Vietnamese gunners, which offered a low probability of success. Anti-aircraft gunners found it difficult to acquire the OV-10 visually through the trees to track the aircraft for a long engagement. They were limited to fleeting shots that seldom found their mark, which allowed pilots to fly routinely at 1,500 feet (Harrison 1989, 87).

By the time Desert Storm occurred, forward area air defense systems included widely proliferated shoulder fired surface to air infrared missiles that could be fired by the common soldier. This presented a much more deadly environment for the OV-10 to operate in and two aircraft were shot down by these systems during the war. The OV-10 was unable to fly overhead enemy forces at low altitude with impunity as it had done during Vietnam. Vietnam pilots found that flying at 1,500 feet kept an aircraft safely above the effects of small arms (Coulthard-Clark 1997, 14). The man portable air defense systems (Man-PADS) of today are effective over 10,000 feet during daylight. Man-PADS are significantly less effective at night since operators find it difficult to visually acquire the aircraft to align their infrared sights. During Desert Storm, the USAF would not allow its single engine F-16 strike fighters to fly below 15,000 feet for much of the war due to the Man-PADS threat (Coln, Sizemore, and Naumann 1991, 127). The OV-10s had to fly at higher altitudes in the Gulf and relied on their magnified infrared systems and binoculars for target detection.

Endurance

Loiter time was one of the OV-10's greatest attributes. A typical mission in South East Asia lasted 4.5 to 5 hours (Air International 1992, 326). The Bronco could loiter for over two hours at a radius of 150 miles with light weapons load and maximum external fuel. The endurance of the Bronco enhanced its success in every mission that it performed. Ground commanders in Vietnam equated the presence of an OV-10 overhead with tactical and emotional security. They had become aware that with an OV-10 on station, air support would be rapid and decisive if contact was made with the enemy. Broncos were required to be on station any time that the Army or Marines had patrols out in the bush. The Broncos would fly over the terrain and keep abreast of the progress and location of each ground unit. If troops made contact with the enemy, the OV-10 would respond immediately by proceeding to the area to assess the situation. The Bronco crew would alert the Direct Air Support Center in route to get CAS aircraft scrambled, provide relief with its own weapons once on the scene, and then remain on station to control the strikers on the target (Coulthard-Clark 1997, 109). During Desert Storm Broncos generally flew missions in excess of three hours, and were airborne twenty-four hours a day.

Communications

The OV-10 had four radios controlled by a CMS (cockpit management system). Three were solid state multi-band (UHF/VHF/FM) radios. The fourth was a HF radio for long range communications. The radios were capable of secure voice and frequency hopping. SAC(A) aircraft are required to operate on a number of radio frequencies. The air request nets are usually HF nets because of the long range that exists between ground forces and air support control agencies. Air direction nets, used for the terminal control of CAS strikes, are line of sight UHF nets for communications between ground forward air controllers and CAS aircraft. FM nets are used to coordinate with ground fire support coordination agencies near the front lines. The Bronco could monitor all of these nets at the same time, and with the CMS it could transmit on

any one or all of its radios simultaneously. The situational awareness of the OV-10 crews was greater than that of any other individual agency in the air support structure due to its outstanding communications suite and proximity to the forward lines.

Aircraft Systems

The OV-10 had TACAN, VOR (VHF omni-range), and ADF (automatic direction finding) equipment for navigation. In Vietnam, FAC(A)s would use range and bearing information from TACAN stations to find key reference points on the ground. From these reference points, the crews were better able to interpret map coordinates for position reporting, navigation and targeting (Yarborough 1990, 58). Hand-held GPS receivers were used during the Gulf War for better precision. The OV-10D NOS (night observation system) incorporated a FLIR sensor package with a laser target designator and an automatic video tracker. The FLIR was particularly useful in the Gulf War at finding Iraqi forces both day and night. The laser could be used to provide guidance for laser guided munitions or to provide a laser mark for laser spot tracker (LST) equipped CAS aircraft. The OV-10 could fly slow enough to provide a relatively constant laser to target reference line, which helped to get the strike aircraft into position to acquire the laser mark. Starlight night vision scopes and binoculars were used by OV-10 crews to increase target detection options.

OA-10A Thunderbolt II

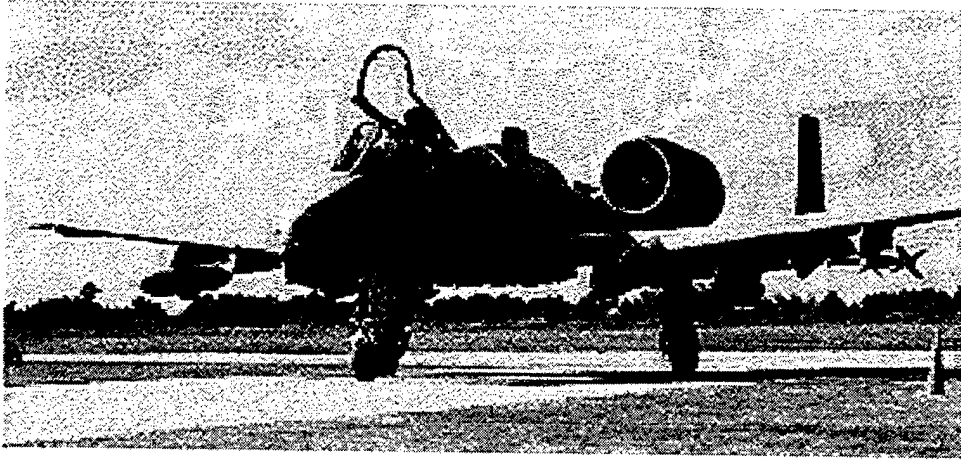


Figure 3. OA-10A Thunderbolt II (*Jane's* 1994, 450)

Primary Function

The A-10 was first USAF aircraft specifically designed for close air support. It is effective against all ground targets, including tanks and armored vehicles.

Features

The A-10 is a low wing, twin-tail, twin-engine turboprop aircraft of metal construction. It has a heavily armored single seat cockpit set well forward of the wing for excellent visibility. It has a low stall speed and excellent short field and rough field performance. The A-10 has a wide tactical combat radius and long battlefield endurance.

Background

The A-10 was first delivered to the USAF in October 1975 in response to requirements set forth in the Attack Experimental (AX) program for a dedicated close air support platform designed to survive on the high threat Cold War battlefield. The AX design was to be low cost and heavily armed with a significant anti-armor capability.

Table 3. OA-10A Specifications (*Jane's* 1994, 450)

Manufacturer:	Republic	Max Speed @ S/L:	380 knots
Introduction Date:	1975	Cruising Speed:	330 knots
Model:	OA-10A	Max Climb Rate:	6000 fpm
Crew:	Pilot	Max Ceiling:	30,000 feet
Dimensions:	Length – 53 feet Wingspan – 57 feet	Max Range:	2130 NM
Max T/O Weight:	51,000 pounds	Combat Radius w/ max weapons load: (no loiter) 540 NM	
Power Plant: 2 x TF34-GE-100 turbofans 9,000 pound thrust each			
<u>Aircraft Systems</u>		<u>Armament</u>	
Navigation:	INS TACAN ADF GPS (hand held)	Fixed:	1 x GAU-8/A 30mm 7 barreled Avenger cannon w/ 1350 rounds 2100/4200 rpm selectable
Communications:	UHF AM VHF AM VHF FM	Disposable:	Up to 16,000 pounds of ordnance. Weapons include: 500,1000, & 2000 iron bombs, cluster bombs, fire bombs, 2.75 and 5 inch rockets, illumination flares, on 3 fuselage and 8 wing stations. AIM-9 Sidewinder missiles, and Maverick missiles.
Night Vision Devices:	Night Vision Goggles		
Laser Spot Tracker:	Pave Penny Pod		
Radar:	N/A		
Infrared:	N/A		
Reconnaissance sensors:	Hand held cameras		

OA-10A Thunderbolt II: Evaluation of the Eight Mission Essential Tasks

Observation

The OA-10A has a large bubble canopy offering good all around visibility. The cockpit is set far forward of the low wing allowing the pilot to have unrestricted vision below the aircraft. Being a single piloted aircraft it cannot benefit from the second set of eyeballs offered by a backseat observer like in the T-6 or the OV-10. The pilot must divided his time between his SAC(A) observation duties and the physical requirements of flying the aircraft. Studies have shown that the aircraft is difficult to see or hear from the ground above 5,000 feet, making it more survivable against visual acquisition threat systems. Pilots in the Gulf used binoculars to aid in

target detection at altitude. The Army generally does not depend on the OA-10 for observation, despite its potential.

Radio Relay

The OA-10A was not used extensively as a radio relay platform for ground forces in Desert Storm. The USAF employed a doctrinal C-130 ABCCC (airborne command control and communications) platform during all ground operations. The ABCCC has the responsibility for providing radio relay services to air liaison officers (ALOs) supporting Army units. On the tactical level, however, the OA-10 with its three radios would be more than capable of assisting ground forces in this manner. At the National Training Center (NTC), OA-10s in support of Army maneuver units are now more routinely used for radio relay (Air Warrior AAR 1996, 3.0).

Reconnaissance in Direct Support of Ground Forces

The nature of modern Army and Air Force operations does not involve the same level of close coordination as Marine Corps ground and aviation elements. The Army employs air and ground cavalry troops for reconnaissance forward of its main ground forces. The helicopter assets of the air cavalry operate far forward of the FLOT to provide the first level of visual and sensor reconnaissance for the Army. Because of this fact, the OA-10 is not used as a primary reconnaissance tool for Army ground forces. Tactical air control parties assigned to the Army by the Air Force operate with forward Army units. These TACPs could employ the OA-10 as an aerial reconnaissance asset should the need arise. As with any fixed-wing tactical aircraft, the altitudes that the OA-10 can achieve are far in excess of what Army helicopters could achieve, giving the OA-10 a much better field of view. At the National Training Center at Fort Irwin, California, Army units have started to use the OA-10 as a reconnaissance tool to locate the elusive opposition force. From high altitude with binoculars the OA-10s have been able to detect enemy forces in training at much greater ranges than conventional Army reconnaissance assets (Air Warrior AAR 1996, 4.3.5).

Reconnaissance in Support of Deep Operations

The OA-10 was used to a great extent during Desert Storm to locate Iraqi positions far past the forward lines. They were assigned the mission of "Scud hunting" by the Joint Forces Air Component Commander (JFACC) (Smallwood 1993, 91). This involved several flights a day by A-10 crews scouring the western portion of Iraq to look for Scud missiles aimed at Israel. Not only were the A-10s successful at finding the missile launchers, they also discovered several other lucrative targets. "Home Depot" and "Hicksville" were names given by A-10 crews to large munitions complexes that were found on deep reconnaissance missions (Stephens 1995, 23). Several strikes were coordinated on those and other sites by A-10 crews. The OA-10 was not designed or intended to fly in support of such deep penetration missions. Some Gulf War A-10s were shot down performing those missions. Generally, deep reconnaissance missions are best flown by high-speed jets due to their greater survivability against high threat air defense systems.

Command and Control

The OA-10 is not generally employed as a command and control platform. The Air Force maintains a C-130 ABCCC at all times when ground forces are deployed. All airborne command and control functions in the Air Force air support control system are handled by the ABCCC. If required, however, the OA-10 with its three radios could carry out command and control functions. Without a HF radio the OA-10 cannot monitor the Air Force Air Request Net (AFARN), but with its UHF and FM radios it could establish the necessary links between all air support and ground agencies.

Terminal Control of Indirect Fires

The OA-10 is not doctrinally tasked with controlling the fire of Army artillery. At the National Training Center, however, OA-10 FAC(A)s have on occasion spotted and controlled Army indirect fire assets (Air Warrior AAR 1996, 3.0). With its outstanding observation the OA-10 is potentially an outstanding spotter aircraft.

Terminal Control of Close Air Support--FAC(A)

The primary role of the OA-10 in the Air Force is to provide airborne forward air control to Army maneuver forces. At the National Training Center, after-action reviews of field exercises have confirmed that the quality of coordination and control of close air support increases exponentially when a FAC(A) is on station (Air Warrior 1996, 3.0). The OA-10 is blessed with good observation and long endurance, and with the ability to shoot white phosphorous marking rockets, making it an outstanding daylight FAC(A) platform. Its ability to locate targets is enhanced by having a laser spot tracker, which can receive coded laser energy from ground laser designator. The OA-10 has been upgraded for the use of night vision goggles since Desert Storm. It is lacking in night target location capabilities compared to other more modern jet aircraft, however, in that it does not have an infrared system or radar.

Terminal Control of Deep Air Support--SCAR

Aircraft involved in the control of deep air support strikes are usually high-speed platforms capable of surviving in high threat air defense environments. Speed is more essential than the ruggedness of the aircraft in this situation. As in the case of the T-6 and the OV-10, the OA-10 is a slow aircraft compared to other tactical jets. During Desert Storm, the Air Force used F-16 Pointer FACs to provide control of fighters engaged in air interdiction against Iraqi ground forces deep in enemy territory. This was done because of the survivability issues associated with deep operations. The F-16s were able to fly at speeds and altitudes that kept them above the higher threat systems. The OA-10 would have been more at risk and was not chosen for these missions.

OA-10A: Evaluation of the Four Aircraft Characteristics

Survivability

The A-10 is one of the most survivable close air support aircraft ever built. The high set, externally mounted engines are armored against small arms fire and shrapnel. If one engine explodes it will not cause the structural break up of the airframe or affect the other engine. The fuel system has all of the fuel lines running across the top of the fuselage away from the direction of ground fire. All fuel cells are self-sealing and are filled with reticulated foam to inhibit the spread of fire. The pilot is surrounded by a titanium "bath tub," which can survive a direct hit from a 23-millimeter shell. The aircraft has redundant aerodynamic flight surfaces, which enables it to fly with half of one wing missing, one rudder, and one elevator (Skattum 1989, 17).

The survivability of an aircraft must be measured against the threat environment that it is required to operate in. The survivability of the OA-10 is perfectly suited to the kinds of threats found near the FLOT where CAS takes place. This environment is dominated by small arms fire, light air defense artillery, and shoulder fired surface to air missiles. The OA-10 can operate out of the range many of these systems, and can soak up a significant amount of damage from these threats if hit. The nature of SAC(A) missions may require the aircraft to loiter near the FLOT for long periods of time. An aircraft like an F-16 would be less survivable when loitering overhead in the same manner as an OA-10 since one well placed round from a machine gun could cause catastrophic damage. That same round may bounce off of an OA-10. The F-16 remains survivable near the FLOT by flying high and using its awesome speed, which limits its exposure to forward area threats. Flying high and fast, however, severely limits the ability of the SAC(A) to perform its mission.

The OA-10 is also one of the most heavily armed aircraft ever built. Its primary weapon is the 30-millimeter GAU-8/A Avenger canon. Each round weighs about 1.5 pounds and has a depleted uranium core for density. It is designed to penetrate the top armor of any known

armored vehicle. Twenty-five percent of the armored vehicles destroyed in the Gulf met their fate at the hands of the A-10 (Stephens 1995, 15). The OA-10 can also carry a vast array of iron bombs, cluster munitions, and air-to-ground missiles. It can fire Sidewinder air-to-air missiles for self-protection. Unguided rockets are carried for target marking, as well as illumination flares. The OA-10 carries chaff and flare defensive countermeasures and an electronic countermeasures pod. A radar-warning receiver is also standard equipment.

Endurance

The OA-10 has outstanding loiter time compared to modern tactical jet aircraft. Its fuel efficient, high bypass turbofans, high lift wing, and large internal fuel load make this possible. The OA-10 can remain on station for one hour and fifteen minutes operating on internal fuel from an airfield 150 miles away (Stephens 1995, 15). This time could be extended with external fuel tanks, but aircraft performance and maneuverability would suffer in the target area. As with the T-6 and the OV-10, the loiter ability of the OA-10 makes it a great platform for SAC(A) missions.

Communications

The OA-10 has a good communications suite consisting of three radios capable of secure voice: one UHF; one VHF; and one FM. The UHF is used to communicate with other aircraft involved in the close air support effort. The FM is primarily used to coordinate with ground forces. The VHF is used for administrative air-to-air communications, but can provide redundancy for other uses. The OA-10 is inferior to the OV-10 in that it has only one crewman to handle coordination on several radio nets. The OA-10 is also lacking a HF radio which prevents the OA-10 SAC(A) from monitoring the Air Force Air Request Net, which is the frequency used by ground units to request CAS. The Air Force structure makes up for any deficiencies in the OA-10's communications flexibility because of the presence of the ABCCC. All ground base air liaison officers have direct access to the ABCCC via doctrinal communications channels.

Aircraft Systems

The OA-10 has an inertial navigation system (INS) for accurate positioning. It also has a TACAN and a UHF/ADF for secondary navigation. The INS is particularly useful for a SAC(A) platform since it allows for accurate navigation to a specific geographic coordinate on the ground such as a target location. Without an INS the OA-10 would be limited to locating a point on the ground by correlating the spot with a map of the area or some other known reference point. The pilot's primary flight instrument reference is a HUD (head up display), which provides altitude, airspeed, and dive angle. Attack symbology for weapons delivery is also displayed. The Pave Penny pod is a laser spot tracker (LST) that can be used for precision attack of ground targets. Once the pod locks onto the spot being designated by the ground controller, the OA-10 can fly directly to the location without error. This is especially important at night because of the increased difficulty in locating targets in the dark. Without the LST, the OA-10 would be limited to locating targets visually with night vision goggles, or by using the tactic perfected in the Gulf War of using the infrared Maverick missile seeker head as a night sensor. The OA-10 has no radar for moving target indication, nor does it have a laser designator for target marking or guiding precision munitions. As mentioned prior, binoculars are carried.

AH-1W Super Cobra

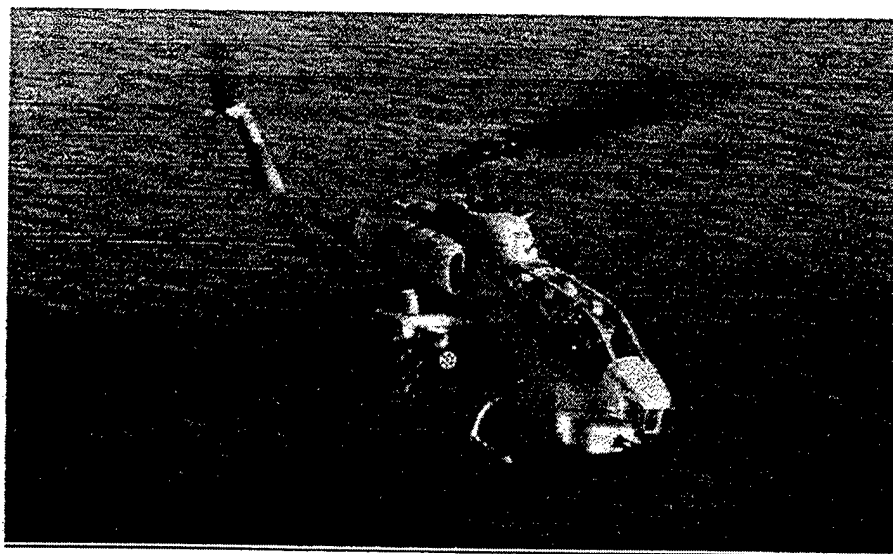


Figure 4. AH-1W Super Cobra (*Jane's* 1997, 500)

Primary Function

The AH-1W provides day and night close air support and airborne supporting arms coordination in support of the Marine Corps. It is a versatile attack helicopter, capable of search and target acquisition, low altitude high-speed flight, multiple weapon fire support, reconnaissance by fire, and escort for helicopter troop lifts.

Features

The Cobra has a two seat tandem cockpit with pilot in rear and copilot/gunner forward. It has two bladed main and tail rotors, a narrow fuselage, and its twin-engine design provides the highest thrust to weight ratio and largest weapons arsenal of any current attack helicopter.

Background

The single engine AH-1 Huey Cobra was America's first purpose built attack helicopter brought into service during the Vietnam War. Several twin-engine versions have served the Marines since. It was first delivered to the Marine Corps with the improved "W" designation in March of 1986. Night capability was obtained in 1993.

Table 4. AH-1W Specifications (*Jane's* 1997, 500)

Manufacturer:	Bell	Max Speed @ S/L:	152 knots
Introduction Date:	1986	Cruising Speed:	150 knots
Model:	AH-1W	Max Climb Rate:	800 fpm
Crew:	Pilot / Copilot	Max Ceiling:	14,000 feet
Dimensions:	Length – 58 feet Rotors – 48 feet	Max Range:	280 NM
Max T/O Weight:	14,750 pounds	Combat Radius w/ max weapons load: (no loiter) 100 NM	
Power Plant: 2 x GE T700-GE401 turboshafts 1723 shaft horse power each			
<u>Aircraft Systems</u>		<u>Armament</u>	
<i>Navigation:</i>	INS/GPS (future) TACAN ADF GPS (hand held)	<i>Fixed:</i>	1 x M197 electrically operated, three-barreled 20mm canon in traversing under nose turret. Gun can track 110 degrees laterally, 18 degrees upward, & 50 degrees downward. 750 rounds available. Maximum rate of fire is 675 rpm with 16 round burst limiter.
<i>Communications:</i> -2 multi-band radios: (ADF capable)	<u>Frequency Range</u> UHF AM VHF AM VHF FM	<i>Disposable:</i>	Four weapons pylons on stub wings. -Up to four 7 or 19 shot 2.75-inch rocket pods. -Up to 8 Hellfire and/or TOW missiles. -Two Sidewinder air-to-air or Sidearm anti-radiation missiles. -Maverick missile under consideration. -Other mini-gun and flare stores, as well as two fuel air explosive weapons possible.
<i>Night Vision Devices:</i>	Night Vision Goggles		
<i>Laser Spot Tracker:</i>	N/A		
<i>Radar:</i>	N/A		
<i>Infrared:</i>	Night Targeting System (NTS)		
<i>Reconnaissance sensors:</i>	NTS / Hand held cameras		

AH-1W Super Cobra: Evaluation of the Eight Mission Essential Tasks

Observation

The Cobra's large canopy provides the pilot and crew with excellent all around vision.

The narrow fuselage allows the crew to see down to the sides underneath the aircraft very well.

The Cobra typically operates below 500 feet, as do most attack helicopters. It uses the terrain to

mask its presence while it surveys the target area. While this adds to the aircraft's survivability, it does not allow the Cobra to achieve the bird's-eye perspective that is normally associated with a high flying fixed-wing aircraft. The Cobra cannot provide the ground commander with the overall disposition of forces in the field. Certainly, if mountainous terrain allowed the Cobra to take advantage of a higher terrain-masked vantage point, better observation could be attained.

Radio Relay

The Cobra has two multi-band (UHF/VHF/FM) radios. These radios allow the aircraft to transmit and receive on the doctrinal FM Single Channel Air Ground Radio System (SINCGARS) and the UHF Have Quick frequency hopping formats. This allows the Cobra to communicate with all tactical ground units that it may support as well as any other Marine aircraft supporting the MAGTF. The nature of low altitude attack helicopter operations, however, limits the aircraft's ability to act as a significant radio relay asset for the ground forces. Generally, an aircraft operating below 500 feet will not be able to achieve line of sight communications with several ground stations much better than a ground based radio. The Cobra has the advantage of being able to move much faster than any ground station to reposition itself for better communications, but a higher flying fixed-wing aircraft will be a much better radio relay platform.

Reconnaissance in Direct Support of Maneuver Forces

The Cobra can reconnoiter a much larger area than any ground reconnaissance asset. The ability of the Cobra to move quickly from one vantage point to the next greatly expands its range and effectiveness as a reconnaissance platform. Magnified day and night optics allow the Cobra to detect targets at a much greater range than ground forces. Night vision goggles and binoculars aid the crew as well. The Cobra provides the ground commander with an outstanding close reconnaissance asset to survey the enemy "over the next hill" or "around the next blind corner."

Reconnaissance in Support of Deep Operations

Deep penetration of an enemy sector normally results in progressively higher threat air defenses. A low and relatively slow flying helicopter would be vulnerable to many radar and infrared guided threat systems. The Cobra is not well suited to support deep operations in most scenarios.

Command and Control

The Marine Light Attack Helicopter (HMLA) community consists of the AH-1W Super Cobra and the UH-1N Huey. The Cobra performs primarily in the close air support roles and the Huey performs the majority of the command and control functions. Whereas the Cobra flies low and close to the action in its attack role, the Huey may fly a higher altitude profile far back out of the threat sector to perform its missions. Although the Huey is not being evaluated in this study, it would be unfair not to recognize that the HMLA does in fact provide critical command and control support to ground forces, especially airborne tactical air coordination or TAC(A).

Terminal Control of Indirect Fires

Helicopters have had much experience as artillery spotters. Cobras performed this role in Vietnam, and continue to train as indirect fire controllers for artillery, mortars, and naval gunfire. The magnified optics and laser range finder of the Cobra, as well as its ability to use GPS for positioning offer all the tools for very accurate deviation and range corrections when adjusting indirect fires.

Terminal Control of Close Air Support--FAC(A)

The attributes of the Cobra previously discussed all contribute to its ability to control CAS aircraft near the front lines. The Cobra can achieve very specific target location and identification from a stable hover using its outstanding targeting systems. This is critical for a forward air controller due to the high risk of fratricide in the CAS environment. Arguably, the Cobra may be better than any other potential FAC(A) at being able to discriminate targets close to

friendly forces. The combination of superior observation over ground based FACs, coupled with its sophisticated targeting systems operated from a stable hover close to the action create a combination unrivalled by the other aircraft in this study. The Cobra's high power laser is perhaps the best laser designator for precision terminal control of CAS aircraft, since the stable hover provides a steady laser to target line for both laser spot trackers and laser guided bombs. The one disadvantage that the Cobra has compared to a fixed-wing FAC(A) is in visually acquiring CAS aircraft as they attack from above. A forward air controller must be able to verify that the CAS aircraft have properly identified the target before dropping ordnance. This is normally done by visually acquiring them in their dive. It is much easier for a fixed-wing FAC(A) such as the F/A-18D to observe other jets at altitude. The fixed-wing FAC(A) also has an advantage in being able to observe the target from the same bird's-eye perspective that the CAS aircraft do. Despite this, the Cobra is an outstanding FAC(A) platform close to the FLOT.

Terminal Control of Deep Air Support--SCAR

Control of deep air support involves the same risks associated with deep reconnaissance. For the same reasons, the low and slow flying Cobra would be very vulnerable to air defenses in the deep battle area. The F/A-18D is much better suited for SCAR as was the case in Desert Storm, and even then the Hornet SCAR flew with an escort because of the high threat level.

AH-1W Super Cobra: Evaluation of the Four Aircraft Characteristics

Survivability

The Cobra has great survivability built into the airframe. The list of safety features includes: two engines; three independent hydraulic systems; two electrical generators; two batteries; three inverters; and self-sealing fuel cells. Defensive systems include a radar warning receiver, an infrared countermeasures set, and chaff and flare dispensers mounted atop the stub wings. Future upgrades may include a laser-warning device and a surface to air missile plume detector. Defensive flying techniques such as nap of the earth flying and terrain masking further

enhance the Cobra's survivability. While flying low generally makes an aircraft more vulnerable to air defenses, the helicopters ability to hide may allow it to remain near the FLOT longer than a fixed-wing FAC(A). Open or urban terrain may put the Cobra at risk. Cobras that fought in the Battle of Khafji found that they had to be wary of gunmen on rooftops and in windows in the upper floors of buildings. The Army Black Hawk that was shot down in Somalia in the famous "Black Hawk Down" scenario serves as a stark reminder of how vulnerable helicopters can be in urban terrain.

The Cobra adds to its survivability with its flexible weapons array. TOW and Hellfire missile provide long range destruction of large targets. The 20-millimeter canon is the Cobra's main weapon and can engage personnel and vehicles. Hydra 70, 2.75-inch rockets are used for a variety of targets, with white phosphorous (WP) warheads used for target marking. A typical FAC(A) load would include 400 rounds of 20-millimeter, two 7 shot rocket pods (WP / HE), two Hellfire, and two TOW missiles. Sidearm anti-radiation missiles can be carried to attack radar guided threat systems such as the ZSU-23-4 anti-aircraft gun, or the SA-8 mobile surface to air missile. The Cobra FAC(A) has the ability to not only protect itself, but also reduce the surface to air threats for other FAC(A) and CAS aircraft.

Endurance

Helicopters have the advantage of being able to operate from FARPs (forward arming and refueling points) on the battlefield close to the FLOT. This maximizes their time on station in support of ground forces. Loiter time for the AH-1W with standard fuel is two hours. This can be increased with the addition of 77 or 100-gallon external fuel tanks, but they are not normally carried tactically. Additionally, helicopters can sit on the ground very near the front at ground idle while waiting to be committed to action, which further enhances their endurance. The Cobra has a significant endurance advantage over the F/A-18D when operating from a FARP. The Hornet, however, will cover much more ground during its shorter time on station, and provide a

much bigger picture of the battlefield to the ground commander. As such the Hornet will have a much larger influence over the battle space than the Cobra, but this support will occur in thirty to forty minute blocks. The Cobra will provide the ground force with enduring close in SAC(A) support, that can be maintained almost indefinitely. The two aircraft, if used in well-planned coordination, can be incredible combat multipliers.

Communications

The two ARC-210 multi-band radios in the Cobra are the same as those found in the F/A-18D and offer the best in modern military aviation communications. Ideally, the SAC(A) must be able to connect with several battlefield agencies at once. These include the various TACPs, CAS aircraft, the DASC (Direct Air Support Center), the artillery Conduct of Fire Net, and mortar and naval surface fire support nets. The OV-10 Bronco could accomplish this with its outstanding four radio communications suite. A high flying fixed-wing aircraft will be able to achieve line of sight with many more agencies than the Cobra. This results in some disadvantages in SAC(A) communications for the Cobra. The hardware is top notch, but the nature of helicopter flight profiles limit its overall command of the SAC(A) communications spectrum. As mentioned before, the UH-1N Huey flies higher profiles for certain HMLA SAC(A) missions, but cannot match the communication range of an F/A-18D flying at a moderate 15,000 feet.

Aircraft Systems

The Cobra is equipped with a highly sophisticated Israeli designed targeting system called the Night Targeting System (NTS). The NTS allows the Cobra to detect, acquire, track, lock on, range, and designate targets under day, night, and adverse weather conditions. The system incorporates a powerful laser for both ranging and designating targets. The ranging function aids in accurate weapons delivery. The designator function can laze targets with coded laser energy for laser spot tracker equipped aircraft or for laser guided munitions. The Cobra crew can choose from three image sources for target detection and acquisition. All three sources

operate together but only one may be viewed at a time. The laser is aligned with the optical sensors.

The Direct View Optics (DVO) offers a 30 degree field of view in low magnification (2x) and a 4.6 degree field of view in high magnification (13x). The DVO is viewed through a telescopic sight called an Optical Relay Tube (ORT). The Charge Coupled Device Television (CCD-TV) utilizes the same reticle as the DVO, but can be viewed on a Multi-Function Display (MFD) or via the ORT. The CCD-TV has a magnification of 5.3x in wide field of view and 34x in narrow field of view. The DVO and the CCD-TV provide long-range target detection during daylight conditions. The Forward Looking Infrared (FLIR) provides night and adverse weather targeting and is viewed through the ORT or on the MFD. The FLIR has a magnification of 2x in wide field of view, 7x in medium, and 25x in narrow. The FLIR image can be electronically doubled to 50x magnification. The images from the CCD-TV or the FLIR can be recorded on a VCR for verification of bomb hit assessment or as reconnaissance footage to be reviewed post flight. The sensors can be boresighted in flight. The NTS sensors are superior to any other reconnaissance or targeting system near the FLOT. The Cobra's ability to discriminate small targets exceeds that of the Hornet with its paltry four power (4x) FLIR and seven power (7x) binoculars.

The Helmet Sight Subsystem (HSS) permits the crew to rapidly acquire visible targets and to direct the firing of the 20-millimeter canon or to cue the NTS sensors toward a particular target area. The pilot or gunner uses the HSS by simply superimposing the helmet reticle over the desired target, then transitions to the NTS for further refinement. The benefits of this system to a SAC(A) are obvious. Any thing that the crew can see can be rapidly acquired by the sophisticated targeting systems for further identification and engagement. No other SAC(A) aircraft has this capability.

F/A-18D Hornet

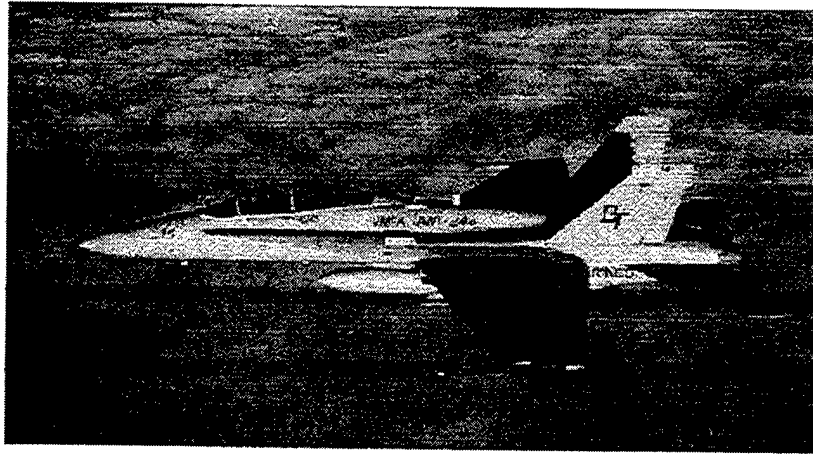


Figure 5. F/A-18D Hornet (*Jane's* 1998, 550)

Primary Function

The F/A-18D was designed to: attack and destroy surface targets, day or night, under all weather conditions; conduct multi-sensor imagery reconnaissance; provide supporting arms coordination; and intercept and destroy enemy aircraft under all weather conditions.

Features

The Hornet is a supersonic, carrier capable, multirole, strike fighter. It was the first modern US aircraft designed from the ground up to be equally effective as both a fighter and an attack platform (F/A). The Hornet is a mid-wing, twin-tail, twin-engine low-bypass turbofan aircraft of composite and metal construction. The two-seat cockpit is set forward of the wing for good all around visibility. It has digital fly by wire flight controls and all digital avionics for navigation and target attack. The Hornet has world-class maneuverability and multi-mission capability.

Background

The F/A-18D replaced three aging aircraft in the Marine inventory: the A-6 Intruder; the RF-4B Phantom; and the OA-4M Sky Hawk. This reduced the inventory to a more efficient three

active tactical jet types: the F/A-18 series; the AV-8B Harrier; and the EA-6B Prowler. The F/A-18D also inherited the roles of the retired OV-10 in 1993.

Table 5. F/A-18D Specifications (*Jane's* 1998, 550)

Manufacturer:	McDonnell Douglas	Max Speed @ S/L:	600 knots
Introduction Date:	1989	Cruising Speed:	High sub-sonic
Model:	F/A-18D	Max Climb Rate:	45,000 fpm @ S/L
Crew:	Pilot & WSO	Max Ceiling:	50,000 feet
Dimensions:	Length – 56 feet Wingspan – 36.5 feet	Max Range:	1800 NM
Max T/O Weight:	56,000 pounds	Combat Radius w/ max weapons load: (no loiter)	550 NM
Power Plant:	2 x GE-404-402 low bypass turbofans 10,800 pounds of thrust each (dry) 17,600 pounds of thrust each (maximum)		
<u>Aircraft Systems</u>		<u>Armament</u>	
Navigation:	-INS -INS/GPS* -TACAN *later models	Fixed:	1 x M-61A1 6 barreled gattling gun w/ 578 rounds 4000/6000- rpm selectable
Communications:	-2 multi-band radios: <u>Frequency Range</u> (ADF capable) UHF AM VHF AM VHF FM	Disposable:	Up to 15,500 pounds of ordnance, on 3 fuselage and 6 wing stations. Weapons include: 500,1000, & 2000 pound free fall and laser guided bombs, cluster bombs, fire bombs, 2.75 and 5 inch rockets, illumination flares. AIM-9, AIM-7, and AIM-120 air-to-air missiles. Harpoon, Walleye, HARM, SLAM, Maverick, JDAM, and JSOW precision air-to- ground weapons.
Night Vision Devices:	-Night Vision Goggles		
Laser Spot Tracker:	-Laser Spot Tracker / Strike Camera		
Radar:	-Hughes APG-65 multi-mode air-to-air/ air-to-ground radar set		
Infrared:	-Navigation FLIR -Targeting FLIR		
Reconnaissance sensors:	-ATARS (Advanced Tactical Airborne Reconnaissance System) -Hand held cameras		

F/A-18D Hornet: Evaluation of the Eight Mission Essential Tasks

Observation

The F/A-18D is a good observation platform. The wing is set back behind the cockpit offering good visibility to the sides and front, but limited in the rear quarters. The leading edge root extension of the wing blocks visibility underneath the aircraft. To see directly below, the pilot must roll the aircraft left or right thirty to forty degrees. This makes the F/A-18D inferior physically to the OV-10 and OA-10 as an observation platform. An advantage that the F/A-18D has, however, over the other aircraft in the study is that it can climb very quickly to reach the best vantage point due to its very high thrust to weight ratio. Also, the superior speed of the supersonic Hornet allows it to cover much more terrain than any of the others, extending the range that it can be employed as an aerial observer. Whereas the other aircraft are generally better suited to cover a doctrinal battalion frontage, the F/A-18D can easily service a regiment or brigade. From a perch of 15,000 feet traveling at tactically safe speeds of 300 to 400 knots, the Hornet can survey a huge area while remaining well above most low threat and many medium threat air defense systems. Binoculars, infrared, and night vision goggles assist F/A-18D crews in conducting aerial observation.

Radio Relay

The F/A-18D has two multi-mode (UHF/VHF/FM) radios. SAC(A) platforms in the Marine Corps have an inherent responsibility to aid ground forces with radio relay. Most modern ground to ground tactical radio nets use the frequency hopping FM SINCGARS format (Single Channel Ground Air Radio System). Due to hardware constraints, the F/A-18D has very limited capability to use the SINCGARS format. Most radio relay done by the Hornet must be in the UHF or UHF Have Quick frequency-hopping format. These UHF formats are reserved primarily for dedicated aviation radio nets between air-to-air or ground to air stations. This means that ground commanders requiring radio relay services from a Hornet must coordinate with their

attached aviation liaison personnel. Since every level of the MAGTF structure has attached aviation liaison personnel, this is not an impossible task. It is not as convenient as the system that was in place when the OV-10 was in service. The Bronco could provide relay services directly via the doctrinal ground to ground tactical radio nets. The four radios in the Bronco added to its flexibility in this role compared to the two radios in the Hornet. Thus, the Hornet is not an ideal radio relay platform, but adequate if used within its limitations.

Reconnaissance in Direct Support of Maneuver Forces

The F/A-18D is a particularly effective reconnaissance platform for maneuver forces. Its speed and maneuverability allows it to quickly reconnoiter an area of concern with numerous sensors. The APG-65/APG-73 (aircraft lot dependent) radar of the Hornet has a ground moving target (GMT) mode which acts as a moving target indicator for vehicular traffic. Enemy forces that are moving in tanks, trucks, or armored personnel carriers will show up on the Hornet's radar at ranges well over twenty miles. As the Hornet approaches the indicated vehicles, the crew can switch to the infrared at around five miles for further target identification. Binoculars and night vision goggles can also assist in refining the target identification and location. The capability of the Hornet to find moving vehicles in this manner provides the ground commander with an outstanding reconnaissance capability never before available in a SAC(A) platform. The combination of air-to-ground radar, infrared, night vision goggles, and binoculars give the Hornet the maximum possible flexibility in providing aerial reconnaissance. Additionally, the Hornet's computer can determine the coordinates to any target that it can find with its sensors. No other asset available to the ground commander at the tactical level can match the reach or sophistication of the Hornet.

Reconnaissance in Support of Deep Operations

The F/A-18D made its combat debut during Desert Storm as a Fast-FAC or SCAR platform for the First Marine Expeditionary Force (I MEF). In this role, the Hornet provided the

MEF commander with primary deep reconnaissance information on the disposition of Iraqi forces in the Kuwaiti theater of operations (Moore 1991, 65). Once again, the speed, range and agility of a supersonic jet allowed the Hornet to provide information deep into enemy held territory. The aforementioned capabilities of the radar, infrared, night vision goggles, and binoculars aided the Hornet in its deep reconnaissance mission.

The F/A-18D fleet, as of this writing, is undergoing the fielding of the Advanced Tactical Airborne Reconnaissance System (ATARS). The ATARS will be available in every F/A-18D squadron in the Marine Corps. It consists of four sensors: the Medium Altitude Electro-Optical sensor (MAEO), the Low Altitude Electro-Optical sensor (LAEO), the Infrared Line Scanner (IRLS), and an enhanced Synthetic Aperture Radar (SAR) mode for the existing APG-73 radar. The sensors will provide detailed digital photographs and infrared images up to 25,000 feet above ground level in reasonable weather conditions. The SAR sensor will provide detailed radar images in all weather up to 40,000 feet above ground level at significant standoff from the target area. All data can be data linked to ground stations over 100 miles away. The ATARS is yet unproven in actual combat, but a demanding and successful research and development process indicate that the system will offer the MAGTF a tactical reconnaissance capability unrivaled anywhere in the world. A complete description of the ATARS is included in Appendix B.

Command and Control

The Hornet, being a relatively short endurance jet aircraft, is not the ideal platform for command and control. The limitation of its communication suite also provides challenges to the F/A-18D in this role. Despite these shortcomings, airborne tactical air coordination or TAC(A) is one of its assigned missions. The TAC(A) mission is a command and control intensive mission requiring the Hornet to remain on station for long periods of time, exploiting its radios to their maximum capability. For the Hornet this means flying at high, energy conserving altitudes (above 25,000 feet), often relying on aerial refueling to achieve the required loiter time. The two

radio limitation requires imaginative and usually non-doctrinal use of the MAGTF communication plan to achieve the necessary connectivity to perform the command and control functions. The TAC(A) potential of the F/A-18D pales in comparison to a fuel efficient OV-10 orbiting for three or four hours utilizing its outstanding Cockpit Management System and four radios. For comparison, it would take two F/A-18Ds rotating back and forth from a tanker to cover the same three hour TAC(A) mission that could be covered by a single OV-10. Using three complex aircraft to perform the same mission as a plane as simple as the Bronco is criminal. Unfortunately, since the Marine Corps does not routinely employ a C-130 ABCCC (airborne command control and communications) platform like the Air Force, the F/A-18D is the only fixed-wing asset available for command and control. Since the F/A-18D has no HF radio it is unable to monitor the MAGTF Tactical Air Request / Helicopter Request Net. As indicated in the evaluation of the OV-10, this is a critical requirement for a TAC(A) platform. Overall, the F/A-18D is a less than adequate command and control platform as it is currently employed.

Terminal Control of Indirect Fires

The Hornet's short endurance coupled with the generally slow pace of indirect fire control do not make it the ideal platform for this mission. The sophistication of the Hornet's navigation and targeting system, however, give it significant advantages over any previous SAC(A) platform. As mentioned before, the Hornet can determine the coordinates to any target that its sensors can find. The method outlined in Appendix A shows how the F/A-18D can be employed as one of the best indirect fire controller on the battlefield.

Terminal Control of Close Air Support--FAC(A)

FAC(A) is the most common mission that the F/A-18D is tasked to perform for the MAGTF. All of the advanced capabilities of the Hornet enable it to greatly extend the range that ground forces can detect and engage the enemy. Its range and speed allow it to support a large portion of the MAGTF frontage. The survivability of the aircraft allows it to operate effectively

near the forward line of troops. The F/A-18D can mark targets with white phosphorous rockets or with its on board laser designator. It can also provide the immediate suppression of targets with its outstanding weapons array. The Achilles' heel of the F/A-18D in the FAC(A) role is its lack of endurance over the battlefield. The other four aircraft in the comparison were able to loiter for at least one hour over the target area. In practice, the F/A-18D is limited to thirty to forty-five minutes loiter time in most situations. This provides precious little time for the Hornet FAC(A) to build adequate situational awareness of the ground scheme. F/A-18D FAC(A) support must be planned and focussed at specific key events or areas of concern on the battlefield.

Terminal Control of Deep Air Support--SCAR

Strike Coordination and Reconnaissance (SCAR), previously Fast-FAC, is the supporting arms coordination mission that the F/A-18D is best suited for. It is the mission that made the F/A-18D famous in the Gulf War. SCAR does not require close coordination with the ground forces. This allows the Hornet to use all of its time on station for the purpose of detecting and engaging the enemy. The MAGTF commander in the Gulf used the SCAR missions to wage a very efficient deep battle in the "kill boxes" that defined the Kuwaiti theater of operations. The F/A-18D was used exclusively to seek and destroy Iraqi forces with heavily armed Marine deep air support aircraft. FAC(A) missions may require the F/A-18D to control the CAS strike from start to finish. The physical control of air strikes is much less time consuming during SCAR missions, since the SCAR aircraft needs only to mark the target location for the strikers and leave them on their own to destroy the target. The SCAR aircraft can then go on to find another target for the next group of strikers. In this permissive environment, the Hornet is less hampered by its short loiter time. It can achieve more effect on the enemy in a shorter period of time.

F/A-18D: Evaluation of the Four Aircraft Characteristics

Survivability

The F/A-18D is one of the most survivable aircraft in the world. As with all naval fighters, the Hornet is ruggedly designed to endure the torture of operating off of an aircraft carrier flight deck. It has two engines, two tails, two hydraulic systems, two electrical generators, two motive flow fuel pumps, and two mission computers. Additionally, it has a four channel digital flight control system driven by two separate flight control computers. Virtually every system in the aircraft has at least double redundancy, and in some cases, triple redundancy provided by the auxiliary power unit (APU). Not a single Marine F/A-18 was lost to enemy fire in Desert Storm despite several incidents of battle damage. Hornets that lost engines from surface to air missiles impacts made it safely back to base and flew again the next day (Stout 1997, 153).

The supersonic F/A-1D is by far the fastest SAC(A) platform in the study, adding a significant margin of safety over the other four aircraft. It can carry nearly all aviation delivered ordnance in the United States inventory, which offers outstanding offensive and defensive capability. Being equipped with a fighter radar and advanced air-to-air missiles makes the Hornet the only SAC(A) platform that could effectively intercept and destroy enemy aircraft attempting to engage friendly forces on the front lines. A-10s shot down two enemy helicopters in Desert Storm, although it has limited air-to-air offensive capability. The F/A-18D has an effective radar warning receiver, an internal jammer, and defensive chaff and flare countermeasures to round out its survivability features.

Endurance

The F/A-18D has the most limited loiter time over the battlefield of all the SAC(A) aircraft in the study. With a standard FAC(A) mission load it can remain on station for only forty minutes when operating from an airfield 150 miles away. The F/A-18D standard FAC(A) configuration includes a full load of sixteen 5-inch Zuni rockets for marking, two fuel tanks, an

infrared targeting pod, a laser spot tracker, one 500 pound Mk-82 bomb, and two Sidewinder air-to-air missiles. The loiter time is calculated at 15,000 feet while maintaining 400 knots true air speed for the full forty minute period. Aggressive maneuvering in the target area will reduce the time on station considerably. With a TAC(A) mission load of two fuel tanks, the infrared and LST pods, and the two Sidewinders, the Hornet can loiter for eighty minutes at 25,000 feet and 400 knots. Endurance profiles are shown in Appendix D and are calculated from a common route flown by F/A-18Ds from Marine Corps Air Station (MCAS) Miramar, California to MCAS Yuma, Arizona training areas 150 nautical miles away. These figures represent about half the endurance of the OA-10 and about one third that of the OV-10 and the T-6 in similar roles. It is obvious that the F/A-18D's endurance compares miserably to previous SAC(A) platforms. Tankers must be available to enhance the F/A-18D's effectiveness.

Communications

The F/A-18D has two multi-band (UHF/VHF/FM) solid state radios. The radios are capable of secure voice and frequency hopping transmission and reception. Both radios have a direction finding capability. The antennas of the Hornet have limited ability to support the FM SINCGARS format. Normally, the Hornet can communicate over 150 miles with line of sight to the other station. With FM SINCGARS, the Hornet is limited to less than twenty miles. Since most tactical ground radio nets are in this format, this represents a significant limitation for the Hornet. Two radio nets are of specific concern: the Artillery Conduct of Fire Net and the Tactical Air Control Party (Local) Net or TACP(L). The Artillery COF Net is the primary indirect fire control net for the MAGTF, and the TACP(L) Net is the primary net used for administrative coordination of close air support between air liaison agencies. Both nets are doctrinal nets that SAC(A) aircraft have historically been required to operate on. Another significant limitation for the F/A-18D is the fact that the two radios are interconnected. This means, for example, that the pilot cannot use radio number two while the weapons systems officer is using radio number

one. The OV-10 crew could utilize any or all of their four radios simultaneously. The communication challenge that is already presented to F/A-18D crew by having only two radios is exacerbated by the fact that the crew can't split up the workload. Typically, two seat tactical aircraft in the military such as the OV-10, the F-4, the OA-4, and the F-14 do not suffer from this design flaw.

Aircraft Systems

The aircraft systems of the F/A-18D are world class. The Hornet's APG-65/73 radar has all of the same basic capabilities as any other modern American fighter for the attack of aerial or surface targets. The radar has a Ground Moving Target (GMT) mode that is a particularly important SAC(A) asset. The GMT radar mode can detect moving vehicles on the ground at ranges exceeding twenty miles (unclassified). GMT mode allows F/A-18D SAC(A)s to detect enemy tanks, trucks, and armored personnel carriers long before they could become a threat to friendly forces. Once a target is detected on the radar, the navigation system and all of the other sensors can be cued to that target for further identification and attack. All F/A-18D aircraft can carry any of three external pod sensors to enhance mission capabilities.

The Laser Detector Tracker (LDT) is derived from the Pave Penney laser spot tracker found on the A-10. The LDT is a laser spot tracker that can intercept coded laser energy from an airborne or ground laser designator such as the Modular Universal Laser Equipment (MULE). Once the LDT "sees" the laser energy reflecting off of the target, the pilot can lock all of the aircraft's targeting systems onto the target for destruction by any ordnance that the aircraft may be carrying. This is different from using a laser to guide a laser-guided bomb in that the LDT allows the aircraft itself to lock on to the target, rather than a particular piece of ordnance. The LDT also has a Strike Camera which will automatically take twenty frames of the target to record bomb hit assessment (BHA) every time the aircraft employs a weapon. The LDT is carried on the right fuselage station.

The Navigation FLIR (NAVFLIR) is a pod that is fixed forward and aligned with the aircraft's longitudinal axis. It projects an infrared image on the pilot's head up display (HUD) providing him with an infrared "window" into the night. It is effective at low altitude to allow the pilot to see the terrain ahead of the aircraft in even the darkest conditions. It aids in target detection and refinement once the pilot points the nose of the jet into the target area for attack. The NAVFLIR is also carried on the right fuselage station, which means that the crew must choose between carrying an LDT or a NAVFLIR. The SAC(A) will normally choose to carry the LDT if possible to enable ground forces to use laser designators to help cue the Hornet's sensors to a particular spot on the ground. This is especially important at night.

The Targeting FLIR (TFLIR) is a pod with a rotating head that can be traversed in all directions to allow the F/A-18D crew to use the infrared spectrum for reconnaissance or to target enemy locations. The TFLIR can be used in one of two basic ways. The crew can type in the coordinates of known locations of interest and through the inertial navigation system, command the seeker head to automatically "look" at the desired spot on the ground. Second, the crew can search for targets of opportunity by slewing the seeker head around manually. The TFLIR is carried on the left fuselage station, and like the LDT, will always be carried by an F/A-18D SAC(A) if possible. The TFLIR has a four-power (4x) zoom to aid in stand off target detection of vehicle size targets. The TFLIR is not optimized for locating small targets.

All three pods are carried on stations that would otherwise carry radar guided air-to-air missiles, thus limiting the F/A-18D SAC(A)'s offensive air-to-air capability. Air superiority is a condition for effective close air support and interdiction so loss of some air-to-air capability by the SAC(A) is normally of little concern. If the threat level is high, then the F/A-18D SAC(A) may fly with an escort as was the case in Desert Storm. Also, all three pods employ either laser or infrared sensors. These sensors are all degraded in poor weather conditions which will affect the SAC(A)'s capability in that environment.

The Advanced Tactical Airborne Reconnaissance System (ATARS) described in Appendix B gives the F/A-18D the world's most advanced tactical airborne reconnaissance capability. The Navy's F-14 Tomcat still employs the aged Tactical Airborne Reconnaissance Pod System (TARPS), but it is limited to chemical photographic images unlike the ATARS which provides digital photographic, infrared, and synthetic aperture radar images that can be data linked over one-hundred miles away. As TARPS is retired from the inventory, the ATARS equipped F/A-18D will stand alone as the only American tactical airborne reconnaissance platform.

The advanced aircraft systems of the Hornet allow it to perform its SAC(A) missions in the widest possible variety of tactical scenarios. All elements of the Marine Air Ground Task Force must be familiar with the systems and capabilities of the F/A-18D.

Summary of SAC(A) Analysis

The purpose of the analysis phase was not to determine which of the five SAC(A) platforms was best by direct comparison. Each aircraft was evaluated based upon the service that it provided in the conditions in which it was employed. Capabilities were compared to the needs and technologies of the time. The analysis showed what requirements have been placed on SAC(A) platforms as warfare has evolved, and how the aircraft have succeeded or failed in meeting those requirements. These lessons provide insight into how best to employ the F/A-18D as an airborne supporting arms coordination platform.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The historical analysis in chapter 4 validated the importance of airborne supporting arms coordination aircraft since the earliest beginnings of military aviation. The analysis of the five aircraft chosen for the study gave insight into how SAC(A) employment has evolved, and it highlighted the strengths and weakness of SAC(A) platforms since the Korean War period. The characteristics of the SAC(A) platforms had a significant effect on their ability to execute the mission requirements placed on them. The F/A-18D proved itself in combat as a SCAR platform during Desert Storm. Since the retirement of the OV-10, the F/A-18D has had very little combat experience acting as a FAC(A) or TAC(A) platform for a doctrinal Marine Air Ground Task Force. The weaknesses of the F/A-18D as a SAC(A) platform, endurance and communications, were primary strengths of the OV-10. The sharing of SAC(A) duties between the Hornet and Marine attack helicopters was to have the combined affect of replacing the Bronco. The doctrine of how to clearly define the SAC(A) mission requirements for each does not exist. Despite this fact, lessons learned from the employment of previous SAC(A) platforms suggest solutions to develop doctrine to best employ the F/A-18D to meet future challenges.

F/A-18D Strengths and Weakness as a SAC(A) Platform

The analysis phase brought out the areas of strength and weakness in the F/A-18D as a SAC(A) platform. The relative importance of these attributes can be concluded from the experiences gained from the use of SAC(A) aircraft over the broad spectrum of warfare. The following discussion attempts to suggest ways to maximize the employment of the F/A-18D based on its present attributes, and how to improve the aircraft for the future.

Strengths: Survivability

The survivability of the F/A-18D is clearly superior to any previous SAC(A) aircraft. The inherent advantages of speed and maneuverability come from being a fourth generation supersonic fighter design. This puts the Hornet in the same category as the most advanced operational aircraft anywhere in the world. Most available modern defensive systems are incorporated in the Hornet. As technology is improving, planned upgrades to the F/A-18D will include an improved radar warning receiver, an improved internal jammer, and twice the current number of chaff and flare defensive countermeasures. The survivability features of the Hornet will carry the aircraft well into the twenty-first century.

Strengths: Aircraft Systems

The F/A-18D has more versatile and modern aircraft systems than any former or present SAC(A) platform. In fact, the F/A-18D is arguably the most versatile combat aircraft in the world. Systems include the following: air to air / air to ground radar; targeting infrared pod; navigation infrared pod; night vision goggles; laser spot tracker; INS/GPS navigation (older lots have INS only); and the Advanced Tactical Airborne Reconnaissance System. No other aircraft in military service can match that range of capabilities.

Weakness: Autonomous Precision Target Identification

The outstanding speed, range, and ability to climb rapidly out of harms way makes the Hornet incredibly survivable as a SAC(A) platform, but serves as a disadvantage when trying to determine friend from foe on a cluttered battlefield. Low and slow flying aircraft such as the T-6 Mosquito and the OV-10 Bronco could get close enough to the action to tell individual soldiers apart in the hills of Korea and the jungles of Vietnam. Flying at 1,500 feet at 150 knots over Vietnam, the Bronco could look between the trees and identify bunkers, machine gun positions, and other tactically significant targets while maintaining relative safety above small arms fire, which was the main threat. The proliferation of shoulder fired surface to air missiles makes a low

and slow flying fixed wing aircraft very vulnerable on the modern battlefield. The F/A-18D has to make a very high speed pass to be survivable when flying at low altitude to identify a target in close proximity to friendly forces. This makes target identification difficult and puts the aircraft at considerable risk. Aircraft systems such as the TFLIR with its four-power (4x) magnification can be used at safer altitudes to detect the presence of vehicle-sized targets, but cannot accurately identify a vehicle as friendly or enemy without external verification. The verification may be as simple as a confirmation that no friendly forces are operating in the area where the vehicles were detected. Seven-power (7x) binoculars are standard equipment for daytime missions, and do aid in target detection and identification. Using unstabilized binoculars from an aircraft is difficult, however, and small targets cannot be accurately identified from standoff ranges.

A potential solution to aid the F/A-18D in discriminating targets from safe altitudes is the acquisition of stabilized optics. One system already exists within the military system: the Fraser-Volp M-25 stabilized binocular system, NSN 1240-01-410-7418. The system is described in detail in the product information included Appendix C. The system is basically a fourteen-power (14x) gyro-stabilized binocular that has been tested by Israeli forces from jet aircraft. The system also employs digital camera capability as well as a night vision capability. This simple and inexpensive technology is currently available through existing government contracts.

Weaknesses: Endurance

The major strengths of the T-6 Mosquito and the OV-10 Bronco were the fact that they could remain over the battlefield for hours providing a continuous airborne presence to support ground maneuver forces. In the case of the T-6, the aircraft was unarmed, worked in an area with no navigational aids, and had only one radio. The T-6 was not only the most archaic SAC(A) aircraft chosen for this study, it was perhaps the most obsolete aircraft flying over the skies of Korea in 1951. At the outbreak of the war, jet aircraft capable of speeds approaching the speed of sound were in service in the Air Force, Navy, and Marine Corps. Additionally, some of the most

advanced propeller designs of World War II were still in service. The T-6 was clearly inferior to other advanced aircraft in the theater. Despite this fact, ground commanders credited the Mosquito with "tactical and emotional security." They associated the presence of the T-6 with responsive and accurate close air support. The conclusion that must be drawn from the success of the T-6 was that its greatest asset was simply that it was there when it was needed. The fact that it was on station whenever ground troops were committed and remained there for the duration of conflict was what made it an outstanding SAC(A) platform. The success of the T-6 highlights the fact that endurance is one attribute of a SAC(A) platform that can make up significantly for weaknesses in other areas. This conclusion is validated by the similar success of the OV-10. Although the Bronco had much improved communications capability and superior weaponry, it was relatively similar to the T-6 when compared to the more advanced aircraft designs of Vietnam and Desert Storm. What made the Bronco an indispensable asset was that it was constantly on station to provide rapid response to the needs of the ground forces.

The fact that the F/A-18D suffers from very short battlefield endurance is a critical weakness of the aircraft as a SAC(A) platform. Despite the sophistication and capability of the aircraft, if it is not available when needed, it is of little value to the ground commander. This weakness was not highlighted during Desert Storm due to the presence of the OV-10 in the Marine Air Wing. In future conflicts, however, the Marine Corps will be without a long endurance, fixed wing SAC(A).

A potential solution to give the F/A-18D better endurance may exist in two areas related to the fuel system of the Hornet. First, technological advances have occurred in the research and development of the Navy's F/A-18E/F Super Hornet, which is their replacement for the F/A-18C/D Hornet currently in naval service. New internal fuel cells have been designed which add 500 pounds of fuel capacity. This would represent a five percent increase in internal fuel for the F/A-18D. The second area of potential improvement comes from using larger external fuel tanks.

The Hornet currently uses two 330-gallon tanks holding 2000 pounds each, but has been tested with 480-gallon external tanks. Canadian Hornets have used the larger 480-gallon tanks for several years. The 480-gallon tanks hold 3000 pounds of fuel each. An F/A-18D SAC(A) carrying two 480-gallon tanks would add 2000 pounds to its fuel load, which would have the affect of carrying a third 330-gallon tank, without the drag penalty. The 2000 pounds of additional fuel would represent a 14.3 percent increase over the normal FAC(A) configuration. All together the additional internal and external fuel would represent a 19.3 percent increase.

The increase of nearly 20 percent more fuel would translate into a significant improvement in endurance for the F/A-18D SAC(A). A Hornet FAC(A) with three 330-gallon tanks could remain on station for 55 minutes compared to 42 minutes for a Hornet with the standard two 330-gallon tanks for SAC(A) missions. This 31percent increase in time on station would ensure better support of Marine ground forces. The third 330-gallon tank, which would attach to the centerline pylon, would severely limit the field of view of the TFLIR, and result in poor handling characteristics for the jet. Three tanks are not used for this reason, but the two 480-gallon tanks could push the time on station over an hour without the ill effects of three 330-gallon tanks. The F/A-18 E/F Super Hornet will use 480-gallon tanks as standard equipment. Presumably, the larger internal fuel bladders and tanks would be easy to acquire since both will continue to be available from the naval supply system for the foreseeable life of the F/A-18D Hornet in Marine Corps service. Fuel figures are listed in Appendix D for comparison.

Weakness: Communications

The fact that the F/A-18D cannot communicate effectively in the FM SINCGARS format limits the SAC(A)'s ability to assist ground units directly with communications on tactical maneuver frequencies. Radio relay services can be accomplished at all tactical levels through the tactical air control party at each echelon from company to division level. Planners must be aware of this and be prepared to exploit the SAC(A) and the TACP to maintain links between maneuver

elements when communications degrade as a result of terrain, interference, or other phenomena. Additionally, the Hornet SAC(A) is severely limited in his ability to control and coordinate indirect fire assets on artillery and mortar conduct of fire Nets. The Naval Surface Fire Support Spot Net is a HF frequency, which obviously cannot be utilized by the Hornet since it lacks an HF radio. Planners must prepare for these limitations when the Hornet SAC(A) is employed. In the case of both the artillery and naval surface fire support, doctrinal air spot Nets exist within current doctrine, but these Nets are seldom established in training. *Operational Maneuver from the Sea* initiatives, as well as lessons learned from the Pacific theater during World War II, demand that SAC(A) aircraft be employed to assist in the effective delivery of indirect fires during the early stages of an amphibious operation.

The problem that limits the Hornet the most in the conduct of SAC(A) missions is the inability of the crew to share communications tasks because the radios are interconnected, which precludes simultaneous radio operations. Hardware and software upgrades, part of the Multifunctional Information Distribution System (MIDS - Link 16), are in development, which will eliminate this limitation. The improvements related to independent forward and aft seat communications center around the new Amplifier Control Intercommunication (ACI) system being developed for MIDS. The MIDS ACI will allow for simultaneous transmission from the front and aft cockpits for both of the ARC-210 UHF/VHF-band voice radios and the two MIDS (Link16) L-band voice channels. There are no limitations other than the obvious requirement that each seat use a different VHF/UHF radio or the MIDS.

The upgraded MIDS F/A-18D communications system will not force a minimum VHF/UHF frequency separation, however safety and other procedures will likely require the two radios to be at least 10 MHz apart to prevent interference. Also, some additional development efforts are being investigated regarding the use of Voice Operated Transmit (VOX) verses a dedicated switch to control the intercom functions between the front and aft seats. These

additional changes are being addressed in the Aft Crew Station Upgrade program for the F/A-18F. The MIDS / ACI retrofit designs and estimates are being developed to aircraft Lot 10 F/A-18C/Ds and the Marine's Reserve F/A-18A/B's. The 15C/16E software build will support this new functionality in fiscal year 2000. ACI hardware will also be available in that time frame.

Weakness: Incorrect Conclusions Drawn from Marine Corps Air Ground Training

The Combined Arms Exercise (CAX) at Twenty-Nine Palms, CA is where Marine air / ground doctrine is tested several times each year. CAX allows the MAGTF to gain valuable experience in the employment of the F/A-18D, and the training and lessons learned there will carry over into combat. Unfortunately, the sterile CAX training environment presents several unrealistic assumptions with regard to the Marine Air Command and Control System (MACCS) and the employment of the F/A-18D.

The Direct Air Support Center (DASC) is the primary agency within the MACCS responsible for the conduct of the close air support effort. At CAX, the DASC routinely operates from the same tried and true communication retransmission sites on mountaintops that ensure near flawless communications through out the range complex. The DASC is in constant contact with all Tactical Air Control Parties (TACP) via the HF Tactical Air Request / Helicopter Request Net (TAR/HR). Adding to the façade, CAX is never larger than a regimental exercise. In fact, the regiment usually only controls one battalion. The TACPs within a regiment include only about fifteen potential stations that might use the TAR/HR Net to request CAS: the Regimental Air Officer, three Battalion Air Officers each with two ground FACs, and three reconnaissance teams. The retransmission sites and the small number of TACPs combine to create a situation which enables rapid response to immediate close air support requests.

The problem created by this sterile CAX scenario is that it does not account for the unpredictable nature of warfare. In Desert Storm, the First Marine Expeditionary Force (I MEF) consisted of two Marine divisions. As opposed to the fifteen or so air liaison personnel that exist

at CAX, I MEF employed more than one hundred potential close air support "requesters" that could use the TAR/HR Net. The terrain was flat offering no high ground to place retransmission sights. The DASC set up forward operating locations in each division area, but this still resulted in over forty potential TAR/HR Net users for each site. Long range HF communication signals bounce off of the upper atmosphere and back to the surface resembling a large sine wave. Where the wave hits the earth, communications are good, but between those points it is poor. It was not uncommon in the Gulf to have clear conversations over HF with Incirlick Air Force Base in Turkey, but absolutely no communication with the DASC only thirty or forty kilometers away. At night, changes in the atmosphere affect the way the HF signal travels, and the quality of communications.

Marines found that not only was the TAR/HR Net overcrowded due to the large numbers of users, but also communication with the DASC was completely impossible at times because of the nature of the HF signal. The Air Force avoided this problem by having an ABCCC available at all times which could be reached using line of sight UHF radios. Marine TACPs relied heavily on SAC(A) aircraft such as the OV-10 to coordinate their air requests. CAX does not prepare Marines for the potential difficulties of TAR/HR communications in other theaters. Also, it does not prepare Marines for the effects on communications in military operations in urban terrain (MOUT). Power lines, tall buildings, and other urban phenomena will affect communications. High flying SAC(A) aircraft capable of achieving line of sight with several ground stations are likely to be the critical link necessary for responsive fire support.

F/A-18D SAC(A)s are still required to conduct critical command and control and radio relay functions for the Marine Air Command and Control System at CAX, despite the sterile environment. These communications are normally focussed primarily maintaining links between units and on reconnaissance and target destruction in support of the maneuver forces. In a real combat scenario, the F/A-18D will be forced to expand his command and control responsibilities

to include coordinating immediate air support requests. The artificially reliable TAR/HR Net at CAX does not prepare the MACCS for this eventuality. Adding to the potential for disaster is the fact that the aircraft normally operate out of the expeditionary airfield located at the Twenty-Nine Palms range complex. This gives the Hornet the maximum conceivable loiter time for SAC(A) missions. The set of circumstances at CAX artificially misrepresents the employment of the F/A-18D as a SAC(A) platform.

Recommendation: FAC(A) Employment

F/A-18D FAC(A) Relevance for Future Operations

Some have suggested in the past that because of the Hornet's success as a SCAR platform in Desert Storm and its limitations in distinguishing targets close to friendly forces, the F/A-18D should not be employed as a FAC(A) in direct support of maneuver forces at all. The argument is that the F/A-18D should be used exclusively as a SCAR platform to support the MAGTF commander's deep battle beyond the Fire Support Coordination Line (FSCL). This would be a grave mistake for several reasons. First of all, it would take the bird's-eye view of the battlefield away from the tactical commanders engaged in the close fight. The necessity to provide an aerial observation platform in support of ground forces is just as relevant today as it was in 1794 when the French balloonist spied on the Austrians in support of the French army. This necessity is just as relevant today. Without an F/A-18D FAC(A), regimental and battalion commanders would be denied the aerial reconnaissance, command and control, and radio relay services that can only be provided by a high flying fixed wing FAC(A) covering a large sector of maneuver space. Sensor reconnaissance using the Hornet's infrared and ground moving target (GMT) radar would not be available to warn leaders near the front of impending threats. Also, it can't be overlooked that the perspective that the F/A-18D FAC(A) has of the target area is exactly the same as the perspective that CAS aircraft will have when they arrive to drop their ordnance.

This enables the F/A-18D FAC(A), with his superior knowledge of the ground situation, to assist in more efficient and effective CAS strikes.

Marine Corps doctrine has evolved into the new concepts of *Operational Maneuver from the Sea* and *Ship to Objective Maneuver*. As Marine forces are phased ashore during amphibious operations from over the horizon, the fixed wing FAC(A) operating from a forward airfield or an aircraft carrier may be the critical link that joins all the elements of the MAGTF. It is probable that he will be among the first with eyes on the objective, and the only MAGTF asset that can provide real time reconnaissance over the broad spectrum of the battle space. Assaulting air and surface waves will fall within the observation of the F/A-18D FAC(A), as well as any threats that may potentially affect their movement to their objectives. During the critical early stages of an amphibious operation, when limited firepower is ashore, the fixed wing FAC(A) provides the combat multiplier that can bring available naval gunfire and close air support to bear on the enemy near beach and helicopter landing sites. The employment of the F/A-18D during *Operational Maneuver from the Sea* will have an overall MAGTF focus during the early stages of the assault, but the focus will quickly change as battalion and regimental landing teams (BLT/RLT) are consolidated ashore. Those ground commanders must have immediate access to the FAC(A) to enhance their efforts in the close fight. Rotary wing FAC(A)'s will have limited capability after long flights from over the horizon until Forward Arming and Refueling Points (FARPs) are established ashore. This will place the bulk of the early airborne supporting arms coordination burden on the F/A-18D. For these reasons, the conclusion must be drawn that the F/A-18D is a vital FAC(A) asset for both the present and future visions of MAGTF operational maneuver.

FAC(A) Planning

FAC(A) assets should be planned for every MAGTF operation. The FAC(A) can provide aerial reconnaissance forward of maneuver forces, maintain critical communication links between

maneuver elements through the TACP Network as ground communications degrade during aggressive movement through the terrain, recommend tactical action to the ground commander based on the FAC(A) bird's-eye perspective of the battlefield, and engaged hostile targets before they can become a threat to friendly forces.

To draw on a simple analogy, the FAC(A) can assist the ground forces in the same manner that a police helicopter assists policemen on the ground during a high speed chase of a criminal. The criminal has no use of the air above him just as the enemy is denied use of the airspace when friendly forces have air superiority. The police helicopter has a perspective of the streets that cannot be matched by ground officers, just as the FAC(A) does on the battlefield. The service that the police helicopter provides is invaluable even though it never fires a shot in anger. The service that a Marine FAC(A) provides is equally valuable, but offers the added advantage being able to employ numerous high technology systems to detect and engage enemy forces. When appropriate, the FAC(A) can attack enemy forces with CAS and indirect fire such as artillery, naval gunfire, and mortars. Just as police officers on the ground are aware of the capabilities of the police helicopter, so must Marine ground commanders be aware of the capabilities of Marine FAC(A)s and how to exploit them to maximum advantage.

FAC(A) Air Plan Architecture

A primary condition for close air support is air superiority. That said, the FAC(A) working near the FLOT would not normally be expected to operate near a high threat integrated air defense system (IADS). The FAC(A)'s most dangerous threat should come from mobile surface to air missile systems, such as the SA-8 Gecko or the Roland, which are generally considered medium threat systems. When these systems are detected they must be destroyed immediately to reestablish local air superiority. Current capabilities allow easy detection of radar emitting threat systems and they can be hunted down and killed if priority is given to their destruction. The FAC(A) must operate in the gray area that exists between low and medium

threat. Low threat systems such as small arms, light anti-aircraft artillery, and man portable surface to air missiles like the SA-7 are not very effective much above 12,000 feet above ground level (AGL). Some mobile radar guided systems like the SA-8 can approach 20,000 feet at their extreme ranges. Presuming permissive weather conditions and visibility, the F/A-18D FAC(A) can operate at around 15,000 feet AGL and be nearly immune to low threat systems and relatively safe from most medium threat systems. If a FAC(A) flies much higher than that he will not be able to distinguish ground targets very well even with binoculars and infrared systems. Flying much below 15,000 feet he becomes more vulnerable. In the course of his mission it is very likely that the FAC(A) will make several excursions below 15,000 to identify or mark targets, but as much as possible, he should limit his vulnerability. The 15,000 foot altitude should be thought of as a "perch" for basic FAC(A) work for operations near the FLOT.

Close air support aircraft must be de-conflicted from the FAC(A) early in the planning. History shows that it is not uncommon to have several CAS aircraft in an area where the fighting is hot. The "Road to Basra" or "Highway of Death" during Desert Storm was a good example. As a basic plan for F/A-18D FAC(A) and CAS planning the altitude diagram in Figure 6 shows how a CAS stack should be constructed.

The recommended CAS stack plan allows the FAC(A) to control all of the airspace at and below 15,000 feet with a buffer between himself and the lowest CAS aircraft in the stack of 2000 feet. If the plan includes an F/A-18D TAC(A), he should occupy the highest altitude to preclude the need for incoming aircraft to fly through his airspace. This particular stack plan represents an optimal design for the Marine Corps training center at Twenty-Nine Palms where the top of the training airspace is at 28,000 feet. CAS aircraft would be routed to a contact point to work for a ground or airborne FAC by the DASC or TAC(A). CAS aircraft entering the area would be vectored into the appropriate place in the stack between the FAC(A) and the TAC(A). CAS aircraft are typically routed from the bottom of the stack, allowing those above to shift down in

turn for their attacks. Obviously, weather and threat level may dictate a different altitude separation plan. Figure 6 represents a standard for permissive weather conditions and a medium to low threat CAS environment.

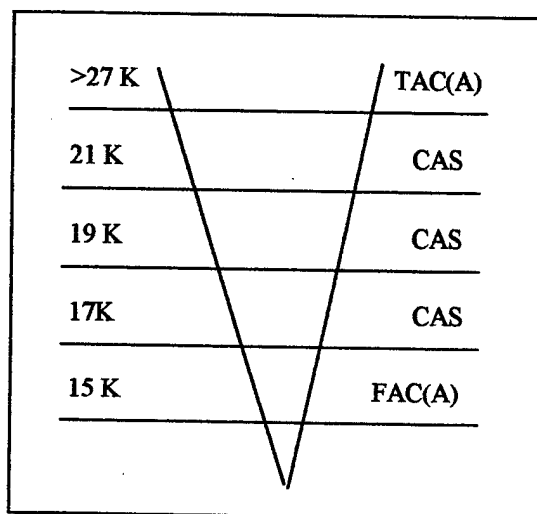


Figure 6. CAS Stack Plan

FAC(A) Configuration for Combat

The F/A-18D has nine weapons stations that are configured to accommodate the needs of the mission. For a typical FAC(A) mission, the Hornet's nine weapon stations should be loaded in the following manner:

1. AIM-9 Sidewinder (short range air to air missile)
2. Eight, 5-inch, white phosphorous Zuni rockets
3. 330-gallon external fuel tank (480-gallon ideal)
4. Targeting FLIR (TFLIR)
5. One Mk-82, 500 pound bomb
6. Laser Detector Tracker (LDT)
7. 330-gallon external fuel tank (480-gallon ideal)

8. Eight, 5-inch, white phosphorous Zuni rockets (16 total)

9. AIM-9 Sidewinder

The Sidewinder missiles provide basic air to air defense for the FAC(A). The sixteen WP Zuni rockets are used for marking targets for CAS aircraft during terminal guidance of air strikes. Sixteen total rockets should be enough to support the FAC(A) for at least two on station periods with one trip to the tanker in between. The two fuel tanks help to extend the endurance of the fuel thirsty Hornet. The targeting FLIR allows day and night target detection and laser designation in allowable weather conditions. The LDT allows the aircraft to receive and track external laser designators for cueing the Hornet to a specific location on the ground. Lastly, the FAC(A) will carry a nominal bomb load for extremis situations when no CAS aircraft air immediately available. The Mk-82 could be replace with a cluster munitions such as Rockeye if desired. The FAC(A) will also be armed with 500 rounds of 20-millimeter ammunition for its internal Vulcan cannon for additional firepower. During night operations, the FAC(A) will replace eight rockets on one station with four illumination flares. The remaining eight rockets may be exchanged for illumination rocket warheads for a better mark at night, although CAS pilots flying at night will be able to "see" WP rockets quite well when wearing night vision goggles.

FAC(A) Task Organization

The speed and range of the Hornet FAC(A) allow him to cover a significant amount of ground in the course of his duties. Previously, Marine FAC(A) platforms such as the OE-1 Bird Dog and the OV-10 Bronco were much slower and could not cover nearly the ground that a jet platform such as the F/A-18D could cover. In open terrain, a typical doctrinal frontage for a mounted battalion (armored or mechanized) may be three to five thousand meters. For a mounted regiment or a brigade the frontage is roughly three times as large. For an OV-10, a battalion sector was easily manageable, but a regimental size area would present challenges. An F/A-18D

FAC(A) could cover this space in a matter of minutes. In modern Marine Corps doctrine the duties of FAC(A) are split between the F/A-18D and the light attack helicopter squadrons (HMLA). The speed and range of the helicopters are not capable of providing FAC(A) support to a regimental area, but routinely cover battalion frontages.

A significant consideration with regard to FAC(A) employment is the aforementioned limitation that the F/A-18D has in identifying targets in close proximity to friendly forces. The Cobra with its NTS and thirty-four power (34x) CCD-TV and twenty-five power (25x) FLIR has a much better chance at picking out small targets near the FLOT. The ability of the Cobra to use the terrain to mask its location, coupled with the ability to use its targeting systems from a stable hover make it a superior FAC(A) platform for close in work. The facts clearly seem to indicate that the proper doctrinal task organization for FAC(A) support is for the F/A-18D to support regiments, and for HMLA FAC(A)s to support battalions. This doctrinal tasking would allow the F/A-18D FAC(A) to concentrate on targeting enemy artillery and second echelon forces just beyond the forward lines. The HMLA FAC(A)s would then be responsible for terminal control of CAS in the area just beyond the observation of ground forward air controllers, but still close enough to friendly forces that the risk of fratricide is high. This is a relatively simple break down of responsibilities, and in fact commonly occurs at CAX but does not exist as specific doctrine in the Marine Air Command and Control System.

Doctrine does not specifically exist for the F/A-18D to operate within a regimental command and control structure. The Regimental Air Officer maintains an FM SINCGARS TACP Local radio net to communicate with TACP teams across the regiment. As stated earlier, the F/A-18D has limited capability to transmit and receive in the SINCGARS format. To get around this problem at CAX, a Tactical Air Direction (TAD) Net is often set aside to act as a de facto "UHF TACP Local" net for the F/A-18D FAC(A) to communicate across the regiment. This often leads to confusion since TAD Nets are for the specific control of CAS strikes. Any

extraneous conversation on a TAD Net could result in bombs being dropped in the wrong area, thus increasing the risk of fratricide. Using a TAD Net for coordination with an F/A-18D FAC(A) is not only inefficient, but dangerous.

I recommend a new doctrinal frequency known as the "Regimental Supporting Arms Coordination (Airborne) Net UHF" for effective F/A-18D FAC(A) employment. Figure 7 shows how it would fit into the MACCS, and how the two radios in the Hornet would be used to conduct the FAC(A) mission. The FAC(A) would always monitor the new Regimental SAC(A) Net UHF on "COM-2" (radio number two) so that all echelons would have immediate and continuous access. Since all echelons have doctrinal TACPs attached, and due to the advantages of line of sight UHF communications, all units within the regiment will always have a reliable communications link to each other. If the Regimental Air Officer tasks the FAC(A) to work directly for a lower echelon, the FAC(A) will communicate on the appropriate TAD Net with the supported unit and CAS aircraft. The DASC will also remain in the informational loop by monitoring the Regimental SAC(A) Net UHF. The situational awareness of the DASC would improve immeasurably by being linked to the one MACCS entity that links the entire regiment. The new Net could use the frequency hopping Have Quick format.

Figure 7 shows how the F/A-18D could be best tasked organized into a regimental structure for employment and communications. Radio number two or "COM-2" as it is called is listed first because it is usually used for coordination, while "COM-1" is used for tactical control functions. The radios would be set up as follows:

COM-2	Regimental SAC(A) Net – UHF / UHF Have Quick
COM-1	Tactical Air Direction Net– UHF / UHF Have Quick

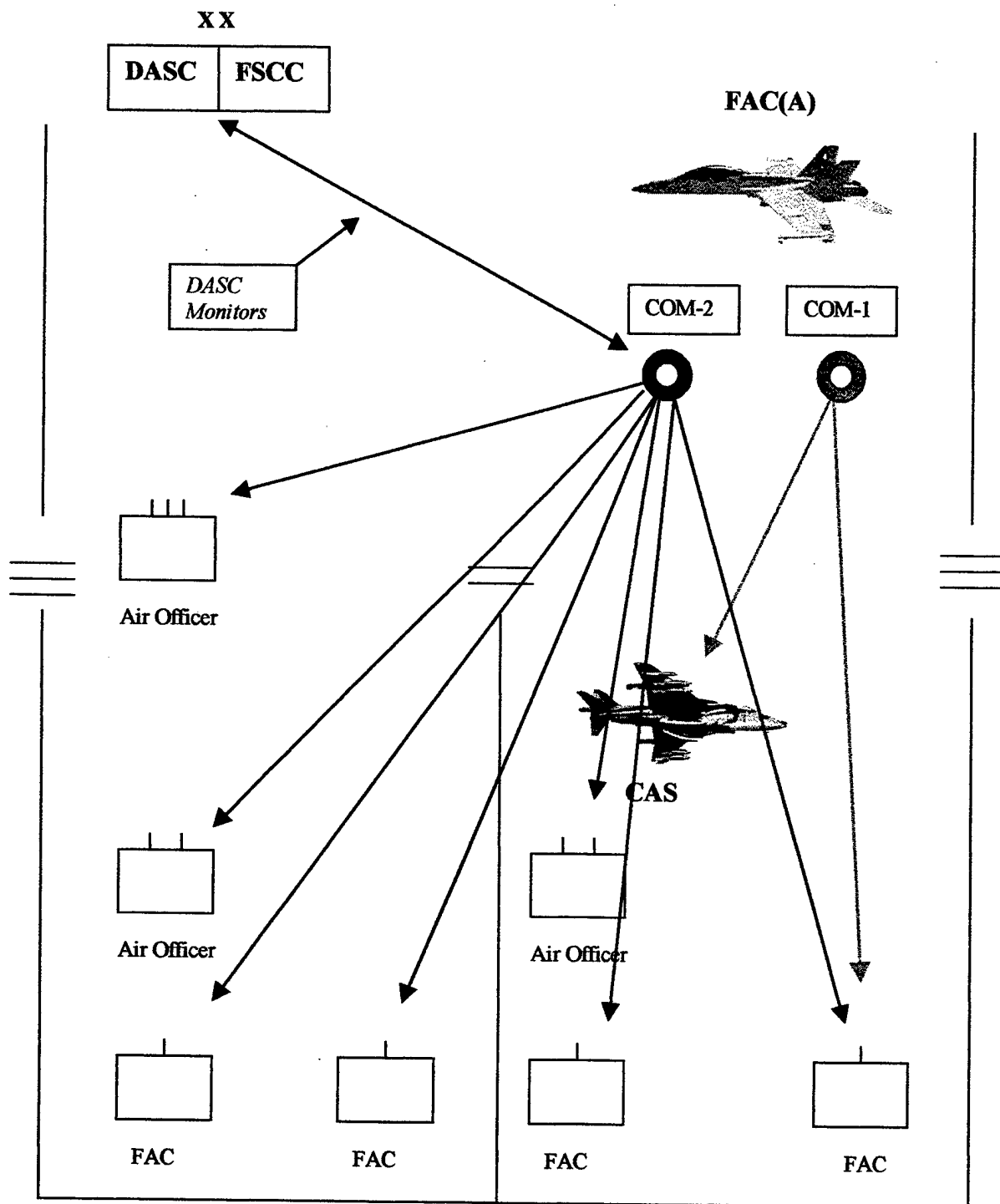


Figure 7. FAC(A) Employment

FAC(A) in the Offense

Offensive operations will naturally be fast paced to take advantage of the principles of warfare such as maneuver, offensive, mass, and surprise. Contact with the enemy is expected. Before crossing the line of departure, the FAC(A) should be airborne at least thirty minutes prior to establish liaison with ground forces, begin aerial reconnaissance, and start building situational awareness. The FAC(A) can expect to be quite busy in offensive operations, especially once contact is made with the enemy. The FAC(A) will expend fuel, ordnance, and loiter time at a rapid rate. To be specific, an F/A-18D FAC(A) flies 150 miles from Marine Corps Air Station Miramar in California to the R-2301 training area east of MCAS Yuma, Arizona. Configured in the standard FAC(A) load describe previously, the F/A-18D can remain on station for forty minutes in a calm orbit above the ground forces at 400 knots and 15,000 feet. If the FAC(A) begins aggressive maneuvering, climbing and descending rapidly to identify the enemy and mark targets for CAS, his time on station will quickly dwindle to twenty or thirty minutes.

Planners should launch two F/A-18D FAC(A)'s to provide continuous coverage for ground forces during offensive operations. FAC(A)-1 must go to the FLOT to begin providing FAC(A) support thirty minutes prior to friendly forces crossing the line of departure. FAC(A)-2 should proceed to a tanker to maintain a full fuel load and monitor the communications of the FAC(A)-1 to maintain situational awareness. Ideally, both aircraft could go to the tanker after takeoff to allow FAC(A)-1 to top off his fuel before going forward to further extend is time on station. If the tanker is less than one hundred miles from the FLOT, FAC(A)-2 should have no trouble maintaining awareness of the ground situation. He will definitely be able to hear FAC(A)-1's communications, and depending on the terrain and line of sight, he may also be able to hear all of the ground TACP communications. As FAC(A)-1 nears the end of his endurance, FAC(A)-2 leaves the tanker in route to the FLOT with a full fuel load. He can easily cover the one hundred miles in less than fifteen minutes. Two F/A-18D FAC(A)'s can continue this

rotation for a significant period of time and insure no gaps in coverage. Long after the two FAC(A)s have expended all of their marking rockets, they can continue to provide support using their laser or artillery to mark targets. Unlike CAS aircraft that complete their mission once all of their ordnance is expended, the FAC(A) can continue to perform his mission with no ordnance just like the police helicopter. The limit of the two FAC(A)s' endurance in this rotation is dictated by the endurance of the crews. In training at CAX, it is not unusual for crews to fly four or five hour missions. The experience of T-6 and OV-10 crews in combat conditions indicate that four or five hour missions are not unreasonable. For planning, a wise approach to schedule FAC(A) support would be to establish three hour blocks for each two ship FAC(A) team. For example, if the ground force was crossing the line of departure at 0800, then the first FAC(A) period would be from 0730 to 1030. The next FAC(A) period would be from 1015 to 1315 to allow some overlap between on and off going FAC(A) teams for a battle hand over. To summarize, FAC(A) planning in the offense should employ pre-planned scheduled FAC(A) support for three hour blocks using two F/A-18D FAC(A)s with tanker support.

FAC(A) in the Defense

Unlike in the offense, forces in the defense may not know exactly when contact is going to be made with the enemy. Intelligence on the enemy disposition will vary with the scenario. On an open desert battlefield like Desert Storm, Marine forces could expect intelligence far in advance of an impending attack by a large armored force. In restricted terrain such as an overgrown jungle or wooded environment like the Vietnamese landscape, knowledge of the enemy's whereabouts may not be established until the first shot is fired. These "troops in contact" situations were commonplace during the war in Vietnam. The FAC(A) must be available to ground forces in the defense to provide the same potential services as in the offense. The FAC(A) is quite likely to be the first to alert friendly ground forces of an attack by the enemy.

The overhead cover provided by the FAC(A) in the defense is generally less chaotic than the profile that the FAC(A) will have to fly when the fighting starts. The FAC(A) will be able to maintain a energy conserving orbit up and down the defensive lines. In the same example cited previously using the 150 mile flight to the working area orbit at 15,000 feet and 400 knots true airspeed, the F/A-18D FAC(A) can maintain forty minutes on station. In a situation like Desert Storm with open desert and primarily an armored threat, the Hornet could climb to 25,000 feet and reduce speed to 350 knots true airspeed and remain on station for a full hour. From 25,000 feet the FAC(A) could use the ground moving target (GMT) mode of the radar to provide early warning of approaching vehicles from well over twenty miles away. Of course in restricted terrain, the FAC(A) may have to fly lower and faster to be effective thus reducing loiter time.

The important point for planning is that one F/A-18D FAC(A) could be launched at a time, with another on ground alert to be launched once the fighting starts. This would then initiate a transition to the same rotation that was used in the offense. Depending of course on the scenario, terrain, and potential of enemy attack, the single FAC(A) airborne could make trips back and forth to a tanker fifty miles away resulting in thirty minute gaps in coverage while he was getting gas. While on the tanker, the FAC(A) would maintain communications with the ground forces and could respond to an emergency call for help within six to seven minutes from fifty miles distant. Simultaneous with contact being made with the enemy, he would call for FAC(A)-2 on ground alert to launch. In summary, F/A-18D FAC(A) planning in the defense should include: one pre-planned scheduled FAC(A) to be airborne for every three hour block of desired coverage, supported by a tanker. A second pre-planned on call FAC(A) will sit on ground alert to cover the same three hour block. The times for each scheduled and on call sortie should be staggered by fifteen minutes to allow the same battle hand over planned for in the offense. Because it is less predictable, tanker support should be closer to the FLOT during the defense to allow quicker response times. This may not always be feasible.

Recommendation: TAC(A) Employment

Marine Corps TAC(A)s have historically been employed in eight mission areas: control of a specific three-dimensional portion of airspace for coordination of CAS; act as a backup DASC; assist in helicopter assault support operations; coordinate reactive suppression of enemy air defense (SEAD) missions; act as on-scene commander for tactical recovery of downed aircraft or personnel; conduct visual reconnaissance; coordinate indirect fires; and act as a deep battle coordinator. The recommendation to doctrinally employ the F/A-18D FAC(A) in support of a Marine regiment, should relieve the F/A-18D TAC(A) of some these eight functions. The TAC(A) should only be required to conduct visual reconnaissance and coordinate indirect fires if a FAC(A) was not present. Additionally, the role of deep battle coordinator is now doctrinally the role of SCAR aircraft. The remaining five functions fall into the arena of airborne command and control, rather than more tactically related hands on work of a FAC(A) or SCAR.

The TAC(A) conducting purely command and control functions may not need to be in close visual contact with the elements that he is supporting. For the F/A-18D TAC(A) this offers a significant advantage in employment options, since it may serve to reduce the Hornet's primary weakness as a SAC(A) platform, endurance. The F/A-18D TAC(A) acting as a command and control platform can operate from much higher and more fuel efficient altitudes. Using the same profile in the FAC(A) example, the F/A-18D TAC(A) would carry the same configuration of the nine store stations with the exception of the Zunis on stations two and eight. Those two stations would be left empty since the TAC(A) should not have a need to carry marking rockets like a FAC(A), and the additional aerodynamic drag caused by the rockets would adversely affect fuel consumption. The 500-pound bomb is deleted as well from the centerline station. The F/A-18D TAC(A) flying the 150 mile trip from MCAS Miramar to the R-2301 training range east of MCAS Yuma could remain on station for one hour and thirty minutes at 30,000 feet at 400 knots true air speed. Adding a third fuel tank to the centerline store station would increase endurance to

one hour and fifty minutes. The addition of the third tank to the TAC(A) would have limited ill effect since the TAC(A) acting purely as a command and control platform would not typically be required to maneuver aggressively. The TFLIR and LDT pods remain on the TAC(A) aircraft for performance calculation since any jet in the squadron could be cycled from TAC(A) to FAC(A) and SCAR. The removal of the pods is time consuming and would not typically be performed between missions, so the F/A-18D TAC(A) can expect to fly with them. That said, their affect on fuel consumption must be considered. Depending on the location of the tanker, the TAC(A) may be able to continue to conduct his mission while transiting to and from refueling as long as communications can be maintained with all the necessary stations. This can further enhance the TAC(A)'s endurance. Fuel calculations are listed in Appendix D.

The Hornet's second primary SAC(A) weakness, communications, must be now be considered. For the TAC(A) to be effective, he must be able to maintain full command of the MACCS communication Network. When acting as an airborne extension of the DASC, the TAC(A) is doctrinally assigned to control the airspace over a Marine regiment. OV-10s that previously performed this function aided ground units with the request of immediate CAS as well as the coordination of CAS aircraft once they arrived on station. The Hornet TAC(A) cannot monitor the HF tactical air request net, so it cannot assist in the request of CAS via the primary doctrinal frequency. There is a second doctrinal frequency, however, known as the Tactical Air Request / Helicopter Request 2 Net or TAR/HR 2. This is a VHF-FM radio net that can be established by the DASC that the Hornet can monitor effectively if it is not established in the SINCGARS frequency-hopping format. Ground units within the regiment could always contact the TAC(A) for immediate CAS on TAR/HR 2, when the Hornet was tasked by the DASC in this manner. TAR/HR 2 is seldom used in practice since the VHF-FM format has limited range, and cannot be exploited by TACPs operating from forward locations far from the DASC. Figure 8 shows how the TAC(A) would employ its radios when assigned to support a regiment.

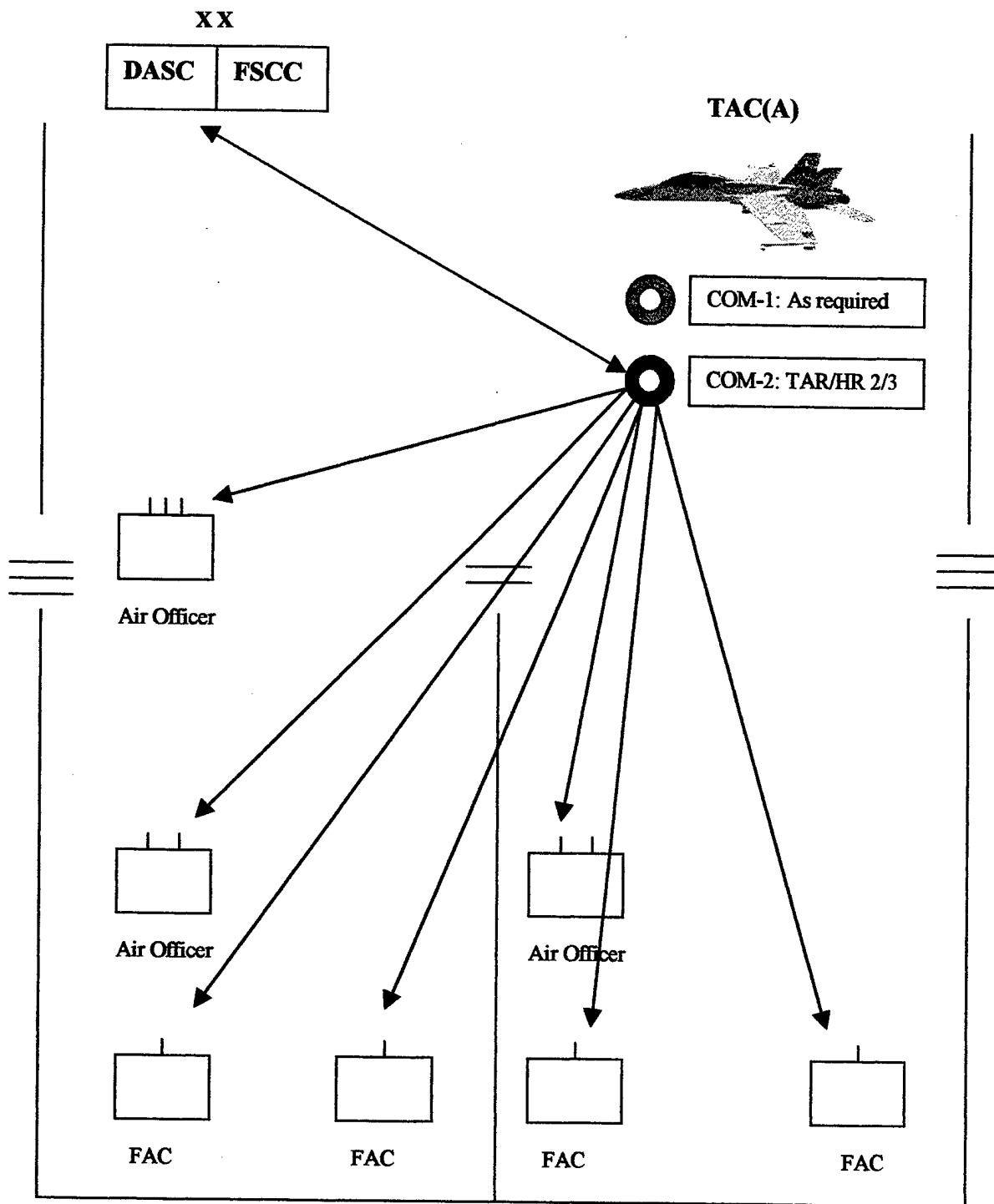


Figure 8. TAC(A) Employment

The TAR/HR 2 Net, exploited in the manner suggested, would become a primary CAS request frequency for ground based TACPs when an F/A-18D TAC(A) is airborne. While TACPs currently do not monitor the TAR/HR 2 Net, they all possess FM radios capable of using the frequency. Figure 8 indicates an option for a TAR/HR 3. This is recommended as a possible UHF option if the TAR/HR 2 VHF-FM is not adequate. This would allow rapid switches by ground FACs on their UHF radios for immediate CAS requests as opposed to switching their FM SINCGARS radio from the battalion or regimental TACP local Nets to the TAR/HR 2 Net. When a TAC(A) has been assigned to control a portion of airspace, he must have knowledge of all air action related to that area. He must be aware of all preplanned and immediate CAS requests submitted, so that he can maintain awareness of the needs of ground units he is supporting. Preplanned requests will appear on the Air Tasking Order (ATO). Ideally, all immediate requests would go through the TAC(A) on TAR/HR 2/3 to be relayed to and serviced by the DASC. This may require the TAC(A) to keep the higher echelon TACPs at the battalion and regiment informed of all CAS requests since they may not be able to monitor all of the shorter range VHF-FM/UHF communications on TAR/HR 2/3. Normally, they would be kept informed on requests for CAS by monitoring the TAR/HR 1, which can theoretically be heard by all stations since it is a long range HF net.

Radio number one or "COM-1", as shown in Figure 8, would be used to cycle through the myriad of other MACCS frequencies that the TAC(A) would utilize to conduct his mission. These other frequencies will include tactical air traffic control (TATC), tactical air direction (TAD), and helicopter direction (HD) nets. The Regimental SAC(A) UHF Net recommended for FAC(A) employment may also be employed by the TAC(A) when required for coordination with TACPs throughout the regiment.

Employment of the F/A-18D TAC(A) may be vital to the success of *Operational Maneuver from the Sea* and *Ship to Objective Maneuver* in future Marine amphibious operations.

Battle space management and communication connectivity are critical to elevating the ground commander's situational awareness. Of all the assets currently available to the MAGTF commander, none can provide this service across the broad spectrum better than an F/A-18D TAC(A) at 30,000 feet with line of sight communications to all echelons of command. The Air Force uses a dedicated C-130 for airborne command, control, and communications. The airborne DASC concept has essentially been removed from the MACCS due to antiquated equipment and lack of extra KC-130 airframes, which are in high demand for aerial refueling. Military operations in urban terrain offer additional challenges for maintaining situational awareness over the battle space. Tall buildings, power lines, and interference from high-powered radio and television transmitters will all have negative effects on communications and ultimately on command and control within the MAGTF. Here again, the F/A-18 TAC(A) may be invaluable. While the discussion focussed on a TAC(A) in doctrinal support of a single regiment, it can obviously provide support at any level of command that would enhance the overall capability of the MACCS to support the MAGTF.

TAC(A) Options

The F/A-18D is not as optimized for TAC(A) missions as the OV-10 Bronco was, but it can be effective with the improved employment doctrine proposed in this thesis. Still, other options may offer a better use of MAGTF resources. Using a multi-million dollar strike fighter as a command and control platform is not very efficient, especially when compared to the OV-10 which did the job much better for much less cost. The cost is not measured only in dollars but in the fact that the Hornet could be using its sophisticated targeting systems to drop tons of bombs on the enemy rather than orbiting with no offensive weapons at 30,000 feet.

Many scenarios may not require both an F/A-18D FAC(A) and TAC(A) to be airborne simultaneously. In these situations, a UH-1N Huey from the light attack helicopter community offers a full range of communications options, including FM SINCGARS, UHF and UHF

HAVEQUICK, as well as satellite communications in a single radio control station. The UH-1N TAC(A) can remain airborne for 1.5 to 3.5 hours when operating from a FARP depending on equipment and personnel load. Two hours are a good planning figure. The Huey can operate for about one hour from an amphibious ship fifty miles over the horizon. The Huey TAC(A) could monitor the TAR/HR 2/3 Net for air requests, as well as the proposed Regimental SAC(A) Net and other MACCS frequencies. With its three ARC-210 multi-channel radios with SATCOM capability the UH-1N is potentially a much better communications platform than the F/A-18D. The Huey does not suffer from the SINCGARS limitation that plagues the Hornet. The Huey is much more efficient than the Hornet as a TAC(A) since it is a relatively simple utility helicopter instead of a sophisticated supersonic strike fighter.

Perhaps the best employment of SAC(A) aircraft to support a Marine regiment would be to task a UH-1N as TAC(A) working in close coordination with the F/A-18D regimental FAC(A). The two aircraft would be mutually supportive, each making up for the weaknesses of the other. The F/A-18D FAC(A) would most likely have a wingman rotating with him every forty minutes or so, while the long endurance Huey would maintain continuity to the overall airborne supporting arms coordination effort. In theory, this represents the original intent of SAC(A) operations after the OV-10 was retired. In practice, however, the architecture has never existed to make it a reality. The use of the TAR/HR 2/3 and the proposed Regimental SAC(A) Net provide the structure. FAC(A) and TAC(A) functions may overlap as the Hornet and the Huey perform in the suggested employment option. This should not be of concern as long as all supporting arms coordination duties are covered adequately.

The airborne DASC could be brought back into routine service as another option to the inefficient use of the F/A-18D TAC(A). With a commitment to upgrade its old equipment with new more capable systems, the airborne DASC represents the best in airborne command and control that the Marine Corps could hope for. The ABCCC C-130 flown by the Air Force

performs the identical functions of an airborne DASC. Considering that the Marine Corps maintains a commitment to combined arms that exceeds that of any other fighting force in the world, it is ironic that the Air Force maintains a far better capability to ensure connectivity between all of its TACPs than the Marine Air Command and Control System. The same modular command and control equipment that fits into the Air Force C-130 could presumably be employed in a Marine KC-130. The Marine Corps is in the process of improving shortfalls in availability of C-130 airframes with the acquisition of the new C-130J over the next several years. Future amphibious operations may take place far from friendly air fields that F/A-18D TAC(A)s could operate from. Marine F/A-18Ds do not presently operate from aircraft carriers, and although this could be an option for the future, it is not likely. An airborne DASC may be the only option that could be flown in from long range to support the command and control needs of the MAGTF during an amphibious operation.

Recommendation: SCAR Employment

The MAGTF commander uses deep air support (DAS) to impose his will on enemy forces in the deep battle and shape the battle space for future operations. Also, DAS may be employed to coordinate attacks on enemy forces in situations where surface forces are not committed or have not landed, such as during the early stages of an amphibious operation. To enhance the effectiveness of DAS operations, the ACE commander will normally assign a MACCS agency to provide the function of deep air operations coordination and / or assign fixed or rotary wing aircraft as strike coordination and reconnaissance (SCAR) assets. Usually, as in Desert Storm, deep air operation coordination is the duty of the TAOC. The TAOC would be MACCS agency assigned to manage the air battle and coordinate the dispatch of DAS aircraft, while the SCAR aircraft can assist in coordinating the attack of DAS aircraft and reporting battle damage assessment. SCAR aircraft provide the ACE commander with an extended look of the battle space.

The ACE commander via the TAOC will task SCAR aircraft with the monitoring and reporting of certain areas of the battle space. During Desert Storm the deep battlefield was divided into kill boxes by the TACC. As SCAR platforms locate targets, this information should be passed to the ACE via the TAOC. The TAOC will allocate DAS assets to attack those targets based on the targeting priorities established by the MAGTF commander. Additionally, if the target precedence list changes or high priority targets are located by external sources, the TAOC can communicate this to the SCAR. The communications between the SCAR and the TAOC are critical but may be difficult due to the extreme ranges that may exist between the two. The SCAR aircraft will operate similar to a FAC(A) as he reconnoiters his assigned area for targets. This may require the SCAR to descend to lower altitudes for target identification, making line of sight communications with the distant TAOC even more difficult.

The Deep Battle Air Control Net provides the means to direct aircraft in the conduct of deep air support missions. This is a doctrinal UHF Net that may be enhanced by an airborne relay to extend line of sight capability. An F/A18D TAC(A) may need to be assigned to provide this long distance relay between the TAOC and the SCAR aircraft. Just as the TAC(A) controls the airspace over a regiment, he can also be assigned as an extension of the TAOC to act as a deep battle manager. The deep battle could be broken up into sectors such as the deep battle area in front of a Marine division. Unlike in the close battle where there are several TACPs on the ground to ensure close coordination with maneuver forces, the deep battle area will be generally devoid of friendly forces. The SCAR aircraft will control most of the deep battle area with the exception of specific areas where deep ground reconnaissance teams are operating. Figure 9 shows how the deep battle could be conducted with a TAC(A) assigned a division deep battle area by the TAOC while coordinating with SCAR and DAS assets.

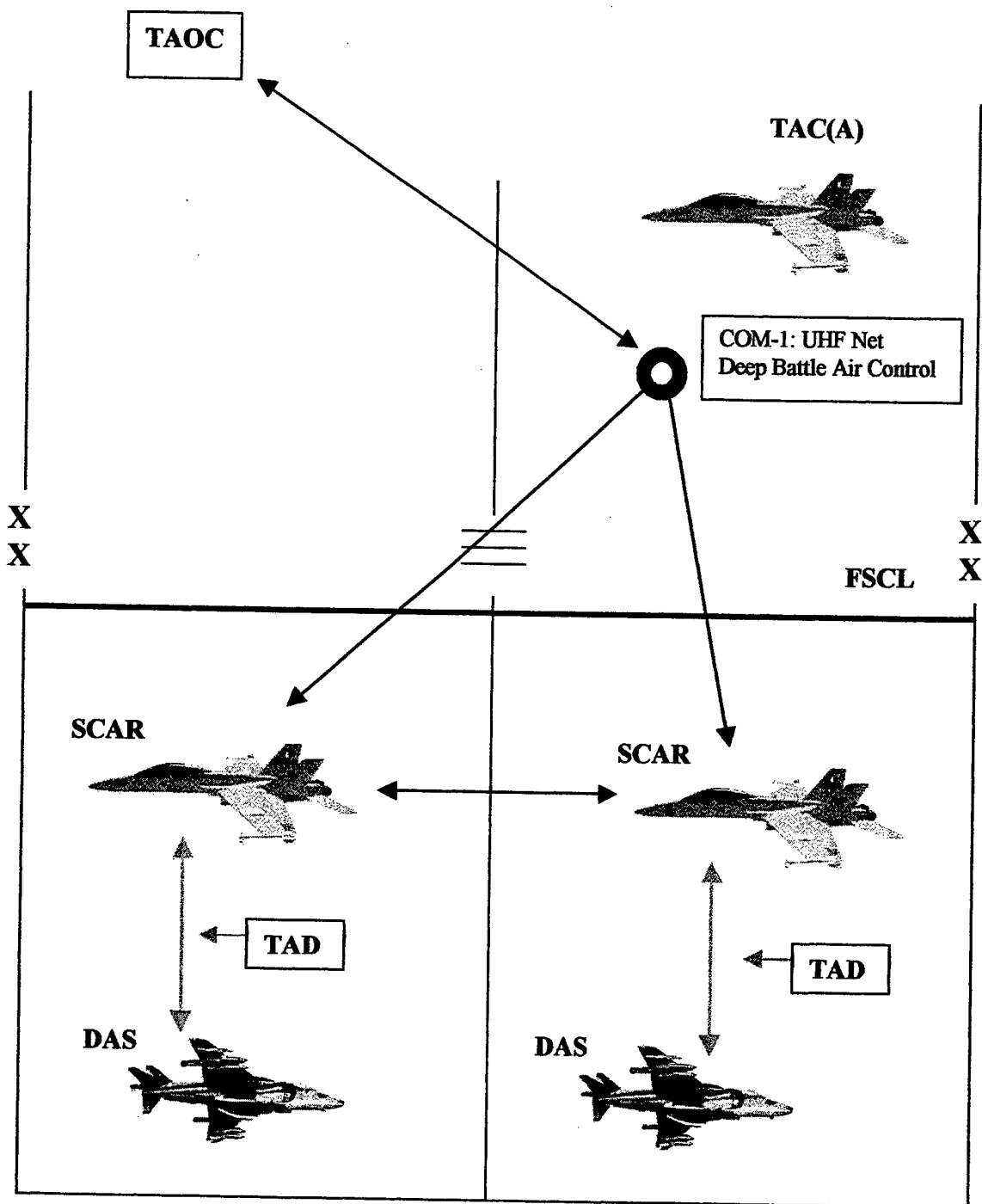


Figure 9. SCAR Employment

As the diagram shows, the TAOC, the TAC(A) and the SCAR aircraft are all connected through the MACCS by the Deep Battle Air Control Net. When DAS aircraft are launched by the TAOC to support deep operations, they will first contact TAC(A) on the Deep Battle Air Control Net to be briefed on the scenario and handed off to the appropriate SCAR aircraft for strike coordination on the assigned TAD Net. One or two SCAR aircraft would be assigned to each division for the deep fight depending on the situation. The communications plan for the SCAR is straightforward. He will use the Deep Battle Air Control Net for reporting targets and surface to air threat levels, and passing battle damage assessment to the TAOC through the TAC(A). He will also use the net to coordinate with the adjacent SCAR if one is present. For the TAC(A), the Deep Battle Air Control Net will be used to coordinate with the TAOC, route DAS aircraft, and pass relevant information to and from the SCAR. The TAC(A)'s other radio will cycle through several potential radio nets. He may need to coordinate with the Air Force ABCCC in a joint environment to deconflict the deep battle. The TAC(A) may also be in direct contact with the JSTARS for targeting information to pass forward to the SCAR.

The SCAR aircraft will configure exactly as the FAC(A) for his mission in most situations. This is a high drag configuration, and will limit the SCAR to 30 to 40 minutes time on station. Tanker support must be well thought out to support all SAC(A) platforms in the theater. Ideally, a tanker track could be positioned to support all forward operating FAC(A), TAC(A), and SCAR aircraft. In a lucrative deep battlefield scenario, SCAR aircraft may have to be cycled in a fashion similar to the recommended FAC(A) rotation to maintain a SCAR presence. SCAR aircraft in Desert Storm flew with single-seat F/A-18C escorts due to the higher anticipated threat levels. The escort typically carried weapons for suppression of enemy air defense (SEAD) and an offensive air-to-air load. The escort had the ability to attack surface targets when DAS aircraft were not readily available. SCAR escort has not been practiced in training since Desert Storm, although it was quite effective during the war.

Summary of Conclusions and Recommendations

The F/A-18D has a limited ability to discriminate friendly from enemy targets in close proximity near the forward line of troops because of its high speed and the altitudes that it must fly at to remain survivable. This fact makes the AH-1W Super Cobra a better close-in FAC(A) than the Hornet in most scenarios. Employing Cobras as battalion FAC(A)s and Hornets as regimental FAC(A)s should result in the appropriate division of labor based on capabilities. This recommendation also takes advantage of the Hornet's ability to cover a larger territory, and allows the F/A-18D FAC(A) to focus on the enemy's second echelon forces, artillery, and forward based logistics. The acquisition of off the shelf stabilized binoculars currently in U.S. military service will improve target detection and identification near the forward lines for very little cost.

The F/A-18D's limited endurance affects its ability to perform all of its SAC(A) missions. Improvements to the Hornet's fuel system with larger available internal and external fuel tanks offer a potential 31 percent increase in time on station. Priority should be given to such a significant improvement, especially since the tanks exist in the current supply system and merely need to be evaluated by the naval test squadron. The testing should be done based on Marine Corps specifications and potential load configurations rather than general testing for naval carrier operations. This should be a high priority for an aircraft that will be in Marine service for at least fifteen more years. The endurance issue is also addressed in the recommendations for improving mission profiles for the F/A-18D in the various SAC(A) missions. Two aircraft rotations for FAC(A) and SCAR, and a well considered tanker plan will ensure availability. Hornet TAC(A) endurance is significantly increased by limiting employment to strictly command and control duties, by allowing it to fly a pure endurance profile at altitude. Well coordinated operations between UH-1N TAC(A)s and F/A-18D FAC(A)s will provide efficient and effective support to Marine regiments, especially in the MOUT environment.

The current communications capability of the Hornet is not optimized for SAC(A) missions. It cannot operate effectively in the MACCS according to current doctrine. Two new frequencies will improve upon this weakness considerably. The Regimental SAC(A) Net will enable the Hornet FAC(A) to best support the ground combat element by connecting the TACPs at all echelons, while also keeping the DASC better informed on the situation at the front lines. New emphasis on the doctrinal TAR/HR 2 VHF-FM Net, or the proposed TAR/HR 3 UHF, will bring back a reliable immediate air request option that has been lacking since the retirement of the OV-10 and the fading employment of the airborne DASC. The recommended deep battle coordination plan will add structure and efficiency to the deep air support operations.

Answers to the Primary and Secondary Research Question

The aforementioned conclusions and recommendations based on careful analysis of SAC(A) platforms since the beginning of military aviation operations have successfully answered the question of how to best employ the F/A-18D in support of the MAGTF. The first secondary question as to the relevance of the SAC(A) to MAGTF operations was proven by the historical analysis of military airpower. The answer to the secondary question of what techniques, tactics, and procedures are required of F/A-18D crewmen to best support the MAGTF are suggested throughout this thesis and are more specifically addressed in appendix A. Taken in total, this thesis represents a realistic and feasible approach to significantly improve the employment of one of the most important assets of the MAGTF.

Significance of Thesis

This thesis is significant because it provides the Marine Corps with a comprehensive plan to better employ one of its most unique and vital assets. The Marine Corps has the well-earned reputation of being the world's premier combined arms fighting force. Combined arms warfare requires the synchronized integration of all available supporting arms with the maneuver of ground forces. The Marine Corps is purposely light on artillery forces due to its expeditionary

nature. CAS is the critical combat multiplier for the MAGTF. No single system within the Marine Corps can facilitate the execution of combined arms warfare as well as the airborne supporting arms coordinator. The SAC(A) is the glue that binds the air and ground combat elements of the MAGTF. The future of the Marine Corps is reflected in the concepts of *Operational Maneuver from the Sea* and *Ship to Objective Maneuver*. This new doctrine demands complete mastery of the littoral battle space to project the amphibious power of the Marine Corps farther and faster than ever before. Critical to the success of any military operation is the commander's ability to make accurate tactical decisions more quickly than the enemy. Because the commander can not be physically present over the entire battlefield, he must have systems in place to give him the tactical perspective that he lacks. The F/A-18D provides the MAGTF commander an unparalleled bird's eye view of the battle space, and gives him the ability to reach out to any echelon of his forces instantly. Perhaps more importantly the F/A-18D gives the commander informational dominance over the enemy in time and space, and the ability to bring combat power to bear on high payoff targets at the critical moment to achieve decisive tactical victory.

Relationship to Previous Studies

There is no evidence to suggest that a similar type of comprehensive study has been conducted to analyze the F/A-18D's employment as an airborne supporting arms coordination platform in support of the Marine Air Ground Task Force. Previous studies have documented the success of the F/A-18D during specific operations, but none have addressed the overall problems with the existing obsolete doctrine that fails to take full advantage of the aircraft's capabilities.

Suggestions for Further Study

The focus of thesis was on improving the employment of the F/A-18D as an airborne supporting arms coordinator in support of the Marine Corps. The information drawn from the analysis of previous SAC(A) platforms suggested possible solutions to the primary research

question. The conclusions and recommendations offer ways to improve SAC(A) operations from the broad perspective of warfare. A detailed analysis of how to develop specific standard operating procedures between the F/A-18D SAC(A), the HMLA SAC(A), and the MACCS was outside the scope of this study. This thesis did, however, lay down the framework for better integration between all the elements involved in providing air support to the MAGTF. I recommend further studies to answer two questions. First, what is the best way to divide specific SAC(A) duties between the F/A-18D and the HMLA community? Second, can *Operational Maneuver from the Sea* be successful without a dedicated airborne supporting arms coordination platform once the F/A-18D is replaced by the Joint Strike Fighter?

Thesis Summary

When the invention of the aircraft was first employed as a military asset over 200 years ago, it was as used to provide aerial reconnaissance on the enemy to give the commander a significant tactical advantage over his adversary. For the two centuries since, the effective use of air power has been debated in every war that aircraft have participated in. While the debates raged on at the highest levels, forces on the front lines have consistently validated the necessity for an airborne supporting arms coordinator to enhance their ability to bring destruction on their enemies. The German contact plane over the battlefields of World War I controlled artillery strikes and provided intelligence on allied positions. Marine spotter planes played a decisive role in coordinating naval gunfire and CAS on Tarawa and Iwo Jima in the Pacific during World War II. The newly formed United States Air Force discarded old concepts of air power and entered the Korean War with shiny new jets and the latest air power technology. Before the war was two months old their dismal failures in providing close air support to the Army forced them to pull the 1930s vintage T-6 Mosquito out of mothballs to provide effective supporting arms coordination and literally turned the war around for the ground forces. Again in Vietnam, the Air Force overestimated technology and entered the war without a dedicated SAC(A) and had to call upon

civilian aviation to provide the O-1 Bird Dog and the O-2 Sky Master in the eleventh hour until the OV-10 could be built.

Despite the lessons of history and the unqualified successes of the OV-10 in Vietnam, and the F/A-18D in the Gulf War, the Marine Corps is following the Air Force down the well worn path of regret. The OV-10 was retired without suitable replacement ending nearly eighty years of fixed wing observation (VMO) squadrons begun by the father of Marine aviation, Alfred Cunningham. *Operational Maneuver from the Sea* will expand the amphibious battle space beyond that which any MAGTF commander has had to consider in the past. Unfortunately, he may not have a SAC(A) to extend his influence when the F/A-18D is displaced rather than replaced by the Joint Strike Fighter in the next fifteen years. Stealth technology will replace the combined arms integration that was once made possible by the SAC(A).

Before the mistakes of history are repeated, the present allows us to avoid the path toward a flawed future. Where steel meets flesh on the battlefield, the SAC(A) has proven its worth since it watched over the Marines marching through jungles of Nicaragua like a guardian angel. The fate of the SAC(A) concept depends on the effective employment of the F/A-18D for the remainder of its service life. We owe it to the MAGTF to employ the "D" to its maximum capability to prove or disprove the importance of the SAC(A) concept to the Marine Corps, rather allow time and technology to declare it obsolete. Regret is of no value once the bullets start flying.

Appendix A

Techniques, Tactics, & Procedures for Airborne Supporting Arms Coordination--SAC(A)

SAC(A) will be one of our primary missions in support of the MAGTF in future conflicts. The F/A-18D, the AH-1W, and the UH-1N share the duties of airborne supporting arms coordination in the Marine Corps. The helicopters will most likely be employed as SAC(A)s in close proximity to the Forward Line of Troops (FLOT). Their ability to use the terrain and hover near the infantry gives them the unique ability to see the battlefield from the ground perspective, and quickly maneuver to an optimal vantage point to control CAS. With the Night Targeting System (NTS), the AH-1W is capable of providing a powerful and stable laser platform for precision CAS strikes. The F/A-18D is certainly capable of working near the FLOT, and has the added ability to work targets in the area which extends beyond the observation of the ground and heli-borne FACs, all the way to the Fire Support Coordination Line (FSCL), and beyond. As a tactical jet, the F/A-18D is very survivable in hostile territory due to its ability to fly above the threat and quickly reposition itself over the terrain. Perhaps the most important advantage of the F/A-18D as a Marine SAC(A) platform is that it has the "bird's-eye view" of the battlefield. The situational awareness (SA) that this provides to the air crew, along with the modern weapons and targeting systems of the Hornet, makes the F/A-18D an invaluable fire support asset for the MAGTF. This discussion will focus on the procedures for FAC(A), as they serve as basics for all forms of airborne supporting arms coordination.

Mission of the FAC(A)

The FAC(A) is an airborne extension of the Tactical Air Control Party (TACP). The FAC(A) extends the range that the TACP detect, identify, and destroy the enemy. He can serve as an additional FAC for the TACP, support a maneuver element without a FAC party, or supplement the capability of a FAC party. In most situations, the FAC(A) will work with and for the TACP. To maintain situational awareness and accomplish his mission, the FAC(A) must continuously coordinate with the supported ground combat element. He should not approach his duties with the attitude that he is there to take charge and save the day. The infantry will continue the fight long after the FAC(A) has "bingoed" home for fuel.

Limitations of the F/A-18D FAC(A)

As with all weapon systems, the F/A-18D has its associated strengths and weaknesses. The key to success for the FAC(A) is to effectively exploit the Hornet's many strengths and find alternatives to minimize its weaknesses.

STRENGTHS

- Survivable (speed / altitude)
- Self Protection capability
- Autonomous marking capability
- A/G ordnance (load/variety/accuracy)
- UHF & VHF communications
- FLIR systems
- Night Vision Goggles
- Laser Target Designator/Ranger
- Laser Spot Tracker / Strike Camera
- Ground Moving Target radar mode
- 2 seat cockpit (shared workload)

WEAKNESSES

- Short time on station (TOS)
- Lack of HF radio (TAR/HR net)
- Limited SINCGARS radio range
- Speed
- Cockpit Visibility
- Single radio operations
- Small target discrimination

Limitations

Time On Station

As with all jet aircraft, the Hornet consumes a lot of fuel. Even with a full fuel load upon arrival to the target area, the FAC(A) can expect 30 to 45 minutes maximum TOS. To maximize his TOS, the FAC(A) must manage his fuel efficiently. If, for example, the FAC(A) is being employed by the TACP for radio relay, he should assume a maximum endurance profile at altitude if tactically feasible. At no time, however, should the FAC(A) put himself at risk for the sake of fuel conservation. While in the threat sector, the FAC(A) must maintain tactical airspeed (at least 400 knots TAS). The FAC(A) pilot must master the art of knowing when to conserve and when to light the burners. From a planning perspective, the best scenario to prevent gaps in FAC(A) coverage would be to launch 2 FAC(A)s at the same time with the first proceeding to the target area, and the second going to the tanker. Ideally, the aircraft at the tanker will be able to monitor the communications of the working FAC(A). As the first aircraft nears the end of his TOS, the second should arrive with a full fuel load to assume the mission with good SA. Time on station is affected significantly by the flight profile flown by the FAC(A) pilot. With a full FAC(A) load out which will be discussed later, an F/A-18D can maintain 40 minutes on station at 15,000 feet MSL at 400 knots TAS operating from an airfield 150 nautical miles away. That is calculated in steady state flight with no aggressive maneuvering, and would apply to a FAC(A) that was simply orbiting over head the FLOT providing aerial reconnaissance and radio relay for the infantry on a benign battlefield. From 15,000 feet the FAC(A) can generally remain safe from low threat systems and still maintain SA on the ground scheme. Once contact is made with the enemy, and the Hornet FAC(A) starts "turning and burning," 40 minutes time on station will quickly dwindle to more like 20.

Lack of HF Radio

Without an HF (high frequency) radio, the Hornet is not able to monitor the Tactical Air Request / Helicopter Request Net. This puts the FAC(A) at a disadvantage since he is not able to assist the TACP in the request of CAS assets from the DASC via the doctrinal request net. As an option, the TAR/HR(2) net is a VHF/FM net that the FAC(A) can utilize for this purpose. Unfortunately, this net is a back up that is not monitored by all of the doctrinal agencies in the Marine fire support coordination structure. As such, "silence is consent" is not in effect on this net since the FAC(A) cannot assume that the Fire Support Coordination Center can monitor his request for air support to intervene and de-conflict. The FAC(A) will have to separately inform the FSCC through the Battalion Air Officer on the TACP Local Net of any requests sent over the TAR/HR(2) Net. It is important that the Air Combat Element (ACE) ensure that the TAR/HR(2) Net be established by the DASC for use by FAC(A)s.

Lack of SINCGARS radio range

The ARC-210 multi-channel radios in the Hornet are excellent in most respects. Their one handicap lies in VHF/FM SINCGARS communication. While the ARC-210 is capable of this format, the lower blade antenna of the F/A-18D is not optimized for SINCGARS. Voice range of less than 20 nautical miles can be expected until the antenna is modified to improve performance. The FAC(A) must be conscious of this limitation. If the TACP(L) Net is SINCGARS, the FAC(A) may be able to talk adequately in the vicinity of the target area. Once the range from ground station increases, communication on that net may be lost. For this reason, the DASC should not establish the TAR/HR(2) net in the SINCGARS format due to the anticipated range that the FAC(A) will need to be able to talk on that net. The artillery should establish a VHF/FM or UHF air spot net for the Hornet FAC(A) to be able to relay calls for indirect fire.

Visibility

Hornet cockpit visibility is not optimized for the FAC(A) role. In order to see targets under the aircraft, the pilot must roll the jet to greater than 45 degrees angle of bank. The OV-10 could see under the aircraft with very little change in AOB due to its high wing and convex canopy. Forward visibility from the back seat is poor, as is rearward visibility from the front. The TFLIR can be very useful in seeing underneath the aircraft.

Speed

The speed of the Hornet can be a disadvantage in the execution of the FAC(A) mission. The Hornet is not able to maximize use of the terrain in a low altitude situation like an OV-10, OA-10, or helicopter. Those platforms can orbit low behind mountains or in valleys with relative ease. The Hornet cannot due to its higher speed and larger turn radius. Low altitude operations present the F/A-18D FAC(A) with a significant challenge.

Single radio operations

The F/A-18D cannot transmit and receive on both radios at the same time. This is perhaps the most severe limitation of the F/A-18D as a FAC(A) platform! Since the Hornet was designed from the beginning as a single-seat platform, no consideration was given to allowing the pilot to talk on both radios at the same time. Aircraft such as the OV-10 and the OA-4M, which were designed as two-seat platforms for FAC(A), allowed the pilot and back-seater to perform multiple coordination tasks separate and apart from each other on different radios. This ability is critical to the efficient FAC(A) procedural control of CAS aircraft, and the simultaneous coordination with ground forces. Studies are under consideration to "de-couple" the radios in the F/A-18D to allow simultaneous transmit and receive on the two radios.

Lack of Global Positioning System

Pre-Lot XIX jets are not yet equipped with GPS. On the modern battlefield, the accuracy of GPS for navigation and targeting is a combat necessity. With the current ring laser gyro INS, crews can expect an average drift rate of .2 to .3 nautical miles per hour. While this may be acceptable for navigation, it is not adequate for precision targeting, and operations in close proximity to friendly forces. FAC(A) crews must be aware of the drift of their INS and perform updates periodically to keep their systems tight. Crews should never trust coordinates obtained solely by the INS without verification on a 1 : 50,000 chart.

Small Target Discrimination

At the altitudes that the F/A-18D must maintain to remain survivable in even a low threat environment, it will be difficult to discriminate targets much smaller than a combat vehicle of tank, truck, or APC size in open terrain. Vehicles under camouflage or dismounted infantry will be difficult, if not impossible, for the Hornet FAC(A) to find. This situation requires close integration and coordination between F/A-18D and HMLA FAC(A)s to ensure that the entire battlefield is covered for aerial reconnaissance. Judicious use of binoculars and the TFLIR can aid the Hornet FAC(A) in finding small targets. The FAC(A) crew should "focus" their reconnaissance effort at key pieces of terrain that support the ground scheme of maneuver, rather than simply "scan" the general area. The WSO should have stored key locations as waypoints, and once in the area, cycle through them by using the NAV DESG function to cue the TFLIR. Once identified visually, a key point on the ground should be surveyed with the binoculars, the NVGs, and the TFLIR eye for activity. If vehicles are expected, GMT radar mode should also be used. The pilots ability to position the aircraft for optimal sensor and visual reconnaissance is critical.

FAC(A) Mission Planning

Enclosure (1) of this document provides a checklist of what information the FAC(A) needs to conduct his mission and where to find it. The crew must have access to the ATO, the Special Instructions (SPINS), and the Operations Order. The FAC(A) crew should focus on the ground Scheme of Maneuver and how the he will integrate into the Fire Support Plan. Sortie flow, tanker flow, escorts, communications, control points, friendly and enemy situation, and relief on station procedures should also be considered. The pilot and WSO must break down the planning duties for their mission. The MAWTS ASP for FAC(A) mission planning should be referenced for specific questions.

Aircraft Configuration

The ideal day VMC aircraft load out for OFP 9C (and higher) equipped aircraft is listed below:

Load out by store station

- 1) AIM-9M
- 2) 2 x LAU-10 w/ 5-inch WP Zuni rockets
- 3) 330-gallon drop tank
- 4) TFLIR (with working LTD/R)
- 5) Single Mk-82 or one CBU
- 6) Laser Spot Tracker / Strike Camera (with film)
- 7) 330-gallon drop tank
- 8) 2 x LAU-10 w/ 5-inch WP Zuni rockets
- 9) AIM-9M

Stations 1 and 9 are standard. Four packs of 5-inch Zuni rockets with WP/RP warheads (16 total) on stations 2 and 8 may provide the FAC(A) with enough marking rockets for two periods on station with a trip to the tanker in between. The 5-inch Zuni provides an easily identifiable target mark under VMC conditions, day or night. Additionally, the 5-inch Zuni is an effective suppression ordnance, giving it a dual role capability (mark & suppression). At night, station 2 or 8 could be loaded with one IMER with 4 LUU-2 illumination flares instead of Zunis. Stations 3 and 7 must have drop tanks to extend the endurance of the Hornet. Station 4 must have a TFLIR with operable LTD/R for a variety of FAC(A) tasks to include: laser mark for LST equipped CAS aircraft; guidance of laser guided munitions; target acquisition; INS update, etc. With OFP 91C, the AAS-38A TFLIR is not capable of acquiring an external laser spot. For this reason, the FAC(A) must carry a LST/SCAM on station 6. With OFP 09-C and the AAS-38B TFLIR, the laser spot track capability may be present in the future, and station 6 could be freed up for an AMRAAM or Sparrow. The LST capability of the "B" pod failed operational evaluation, so this capability may not ever hit the fleet. Station 5 can be loaded with one Mk-82 or CBU to give the FAC(A) a standby strike capability in the event that no CAS aircraft are on station to work a target that requires immediate attention. The Mk-82 should have pilot selectable fins to maximize delivery options. Only one bomb should be carried on the centerline pylon to avoid limiting the TFLIR field of regard. A VER with 2 bombs Station 5 would severely limit the TFLIR field of regard.

Cockpit Setup and Equipment

The following items should be available to the FAC(A) crew:

Day or Night

- ◆2 operable radios
- ◆Moving map & INS
- ◆Binoculars
- ◆1 : 250,000 map(s)
- ◆1 : 50,000 map(s)
- ◆ATO/SPINS
- ◆JTAR format / Note pad
- ◆Call For Fire formats
- ◆9 LINE cards
- ◆SA card
- ◆Relief on station checklist
- ◆MAWTS FAC(A) Handbook
- ◆Squadron in flight guide
- ◆Enemy order of battle recognition book
- ◆Escape and evasion chart and survival guide
- ◆COMSEC material (authentication)

- ◆ACEOI (daily changing frequency book)
- ◆Video Tapes (CVRS)
- ◆Camera: KS-150A/DCS-200
(or compatible 35mm SLR w/100mm lens)
- ◆1 : 500,000 TPC divert chart

Night specific

- ◆2 sets operable NVGs w/ good batteries
- ◆2 working chart lights
- ◆2 working Grimes lights
- ◆2 working flashlights
- ◆2 working finger lights

The most important items that the FAC(A) must have airborne are the ATO, the Special Instructions (SPINS), maps, and authentication cards. A copy of the ATO will ensure that the FAC(A) has all of the pertinent control points, frequencies, call signs, pre-planned CAS missions, special instructions, and control procedures required for his mission.

The 1 : 250,000 JOG AIR chart should have the following information plotted: CAS control points; friendly unit situation to include unit boundaries; fire support coordination measures; enemy situation to include surface to air threat locations and envelopes; tanker tracks; INS update points; and emergency divert airfields. This chart will be used as a planning tool for the FAC(A) to develop his game plan for the routing of CAS assets into and out of the target area. It should provide big picture SA of the entire combat zone. The FAC(A) may not have to use this chart in the conduct of his mission, but will need to refer to airborne from time to time to maintain positional awareness.

The 1 : 50,000 chart should have the following minimum information plotted: fire support coordination measures; maneuver control measures such as phase lines; engagement areas; CAS control points (with optional nautical mile range rings & 10 degree bearing lines faintly plotted); and known threat locations. Additional information that may be plotted includes: friendly maneuver unit situation to include unit boundaries; artillery battery locations; reconnaissance and STA team locations (Surveillance and Target Acquisition); TACP and Forward Observer observation posts (OPs); location of any ground laser designators associated with the aforementioned fire control teams; ground checkpoints; pre-planned artillery targets, groups, and series; enemy situation to include surface to air threat locations and envelopes; and INS update points. This chart could potentially become quite busy and cluttered if all of the listed information is plotted. The FAC(A) should use his judgment in how he prepares his charts for the mission.

Cockpit Setup and Equipment continued

Laminated charts are a training luxury that may or may not be an option in combat. Also, using charts that are neatly cut and pasted to fit the area of operation may not be feasible. FAC(A)s should be prepared to use charts exactly as they are printed from the Defense Mapping Agency with all of the marginal information attached. If lamination machines are available, laminate the 1 : 250,000 JOG AIR charts and use alcohol pens to plot the necessary information. Laminating the 1 : 50,000 charts may not be feasible due to the number of charts of this scale that the crew may need to carry for the mission. The 1 : 50,000 charts should be neatly folded and marked for easy selection airborne. The JOG AIR should be marked to aid in finding the right 1 : 50,000 for a given area. Erasable colored pencils are useful when plotting essential information on paper charts and maps. Bold tip dark lead pencils are best for plotting locations airborne on paper charts. The 0.5 millimeter lead mechanical pencils can poke holes through the paper. As a final note on chart preparation, any INS points that are plotted on a chart should indicate the associated waypoint number for quick reference.

Smart Cards: During the mission planning phase, the FAC(A) can create "smart cards" that will enhance his organization and efficiency in the cockpit. These cards can best be utilized with a two knee board setup for the WSO, who will be responsible for most of the mission execution and communications. The cards should be separated in to two categories: those that the WSO will have to write on during the mission, and those that he will only have to reference for information. The discussion of each card assumes a right handed WSO.

◆Situational Awareness (SA) Card-Enclosure (2)--[Left Knee board #1]

The SA Card may be the most useful of all the smart cards that the FAC(A) will use during his mission. This card is constructed using the 1 : 250,000 chart for reference. It provides the FAC(A) with spatial orientation of the control points, the target area, and the planned attack flow. It also assists in airspace coordination / deconfliction and CAS timing. Each control point is labeled with its associated INS waypoint number. Planned CAS stacks are indicated at points with the 'stack' symbol. This card can be constructed airborne quickly on a blank 5x8 card. With OFP 11C, geographic reference points (GEOREF) can provide horizontal SA via the HSI in lieu of the suggested SA card.

◆FAC(A) Administrative Card - Enclosure (3)--[Left Knee board #2]

The FAC(A) Administrative Card will be used by the WSO primarily to record the ATO information specific to his TOS. He should copy down the pre-planned CAS missions starting with any missions immediately prior to his scheduled TOS which may overlap due to the CAS aircraft being late or the FAC(A) being early. The same logic applies to the end of the FAC(A)s last scheduled TOS. Also included on the card are the code words of the day, the tanker information, and the primary radio frequencies anticipated.

◆JTAR format-Enclosure (4)--[Left Knee board #3]

The FAC(A) must have a copy the JTAR format readily available. Individual JTARs can be written down on the FAC(A)s note pad, using the preprinted JTAR format for reference. The FAC(A) may elect to have several of the preprinted formats available to record each mission. A copy of the JTAR format is on page 25 of the MAWTS FAC(A) Handbook.

Cockpit Setup and Equipment continued

♦COMM Card-Enclosure (5)--[Bottom of Left Knee board]

The communications card shown is a sample standard FAC(A) communications plan. The preset frequencies are organized in such a way that they flow logically from takeoff to touchdown for a typical FAC(A) mission. Certain frequencies can be positioned close to each other to facilitate rapid communication switches in the target area. For example, The TAR/HR(2) Net is located one click up from the TACP(L) Net. The Artillery Air Spot Net is one click down.

♦9 LINE Cards-Enclosure (6)--[Right Knee board #1]

This card is used for the construction of the standard 9 LINE brief. Several of these should be carried by the FAC(A). The card is also used in conjunction with the SA Card to manage the airspace with the stack plans at the bottom of the page. Two stack points can easily be managed by the FAC(A). More than two will increase the work load considerably. The FAC(A) should use odd altitudes at one point and even altitudes at the other to provide vertical as well as lateral deconfliction of CAS aircraft. He should work the aircraft from the bottom of the stack through the target area first, then move the higher aircraft in the stack down to set up for their CAS run. As new aircraft arrive on station, they should be routed to the top of one of the stacks and advised of the other players in their vicinity. BDA for each mission is recorded at the bottom of the card for S-2 debrief.

♦Call Fire format-Enclosure (7)--[Right Knee board #2]

Several artillery/mortar CFF formats should be stored in the FAC(A)'s Nav Bag, with one kept on the right knee board ready for use. The FAC(A) should be ready to give CFF at any time should the need arise. Examples of the most common missions are shown at the bottom of the page. For more complex missions, the FAC(A) should refer to his MAWTS FAC(A) Handbook.

♦WYPT Card-Enclosure (8)--[Right Knee board #3]

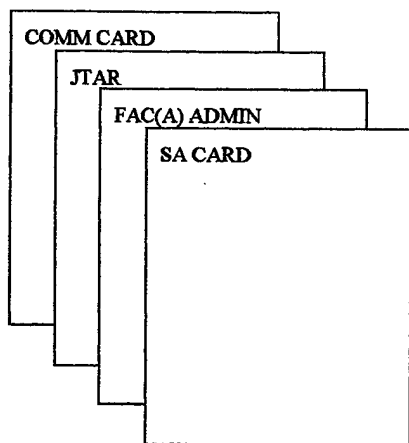
This card is simply used to record the coordinates for the 60 waypoints and 9 marks that are programmed into the INS. The name of each waypoint should be listed on the card, and the spheroid that is in use in the target area. This card is on the right side to allow the WSO to write new waypoints the spare locations on the card.

♦Note Pad--[Bottom of Right Knee board]

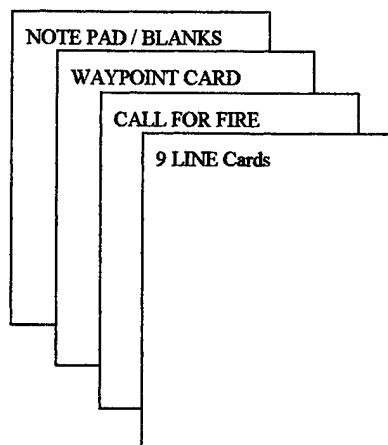
The FAC(A) will have several notes, messages, JTARS, etc. that he will need to write down during the course of his mission. He should have a note pad or blank 5x8 cards to record information in a neat and organized fashion. The standard 5x8 ruled note pads available everywhere are perfect for this purpose.

Cockpit Setup and Equipment continued

Left Knee board



Right Knee board



The diagram above shows how the smart cards would be organized on the WSO's two knee boards. As previously discussed, reference information is on the left (non-writing) side, and mission generated information is on the right (writing) side. The working 1 : 50,000 chart can be stowed near the left hand controller, and quickly pulled out for use. The 1 : 250,000, the ATO, and other charts can be kept in the map case or the WSO's navigation bag. Binoculars can be worn around the neck or in the VMFA(AW)-242 designed center console pouch, and the camera can usually fit in the NVG case. Other potential cards that the WSO may want to carry are photographic logs such as the one depicted in the MAWTS FAC(A) Handbook on page 112 for any "recce photos" that he may take, and any checklists that the FAC(A) may feel important for his mission. A "relief on station" brief is depicted in the FAC(A) Handbook on page 65. The FAC(A) may also want to have the current AKAC authentication sheet readily available in a clear plastic sleeve attached to his knee board. These smart cards may also be used in similar fashion by the FAC(A) pilot.

This section provides one way of preparing and setting up for the FAC(A) mission. The way that these cards are constructed, will ensure that all pertinent information will be easily available airborne, and for the S-2 debrief on deck. This provides a starting point for all F/A-18D air crew. Obviously, if every FAC(A) crew organized for the mission in the same way, preparation for the mission would be faster and more efficient. Each pilot and WSO would know exactly what to expect from the other, and smart cards could be easily shared and understood. Individual preference, however, may cause deviation from what is presented here. It is incumbent on the FAC(A) crew to ensure that they have all of the necessary information for the mission, and that it can be easily accessed airborne.

Tactics

FAC(A) Check In

Just prior to takeoff, or soon after, the FAC(A) can expect to contact the Tactical Air Operations Center (TAOC) on one of the Tactical Air Traffic Control (TATC) frequencies. The TAOC has radar assets, and is responsible for tactical air traffic control. When feasible, the TAOC will switch the FAC(A) to another TATC frequency to check in with the Direct Air Support Center (DASC), which is responsible for running the CAS war. The DASC will advise the FAC(A) of the most recent friendly and enemy situation, confirm the supported unit and their location, and inform the FAC of any CAS missions or JTARs that are relevant to the working area. The DASC will have the FAC(A) switch to a Tactical Air Direction (TAD) frequency to talk to the Air Officer or ground FAC. The FAC(A) should contact the supported unit Air Officer or FAC as soon as possible in route to the target area to quickly gain SA. Upon check in with the supported unit ground FAC or Air Officer, the FAC(A) should receive a brief on the general situation of the target area. A similar brief would be given if the FAC(A) was relieving another FAC(A) on station. This brief should include at a minimum:

- ◆Target area weather

- ◆Enemy Situation

 - Ground scheme of maneuver, location, FLOT,

 - Air scheme, SAM's, AAA

- ◆Friendly Situation

 - Ground scheme of maneuver, fire support coordination measures in effect, FLOT

 - Air scheme, ACAs, CAS or FAC(A) assets on station

- ◆Missions- CAS, artillery, mortar, naval surface fire support

 - In progress, expected, active JTARs, terminal controller, and the FAC(A) support game plan.

In Route

During preflight planning, the FAC(A) should have picked out one or two potential INS update points in the vicinity of the operating area. These points could be plotted near the tanker track, for example, and the FAC(A) could use the time in route to the target area from the tanker to do a FLIR/laser update (or a radar update if bad WX). During a long TOS, the FAC(A) should update his INS periodically to keep a tight system. If the aircraft is GPS equipped this should not be necessary.

Reconnaissance of Target Area

Once the FAC(A) arrives in the target area and has been properly briefed by the TACP, he should make a reconnaissance pass of the zone. This pass should be made at a tactically safe altitude based on the threat. Normally, a pass of 15,000 to 20,000 feet AGL should provide a relatively safe haven above most threats in a low to medium threat scenario. At these altitudes, with good weather, the FAC(A) should be able to identify key locations visually, with binoculars, or TFLIR. The pass should start over the friendly forces to get a feel for the layout of their positions. Short range radar setup (140/6BR/MED/20NM) should provide SA on any other friendly aircraft in the area. As the FAC(A) proceeds into the threat sector, he should immediately evaluate RWR indications. He should make a note of the bearing of any targeting systems and attempt to plot their locations if possible. These systems, if present, should be neutralized ASAP by artillery or air strike to ensure a permissive CAS environment. The FAC(A) should then get familiar with the layout of the enemy ground forces, and make note of the locations of priority targets such as artillery, tanks, mortars, etc. The FAC(A) should also attempt to establish a frame of reference for distances on the ground using his chart of the area. For example, the distance between a

bridge and a road intersection may equate to 1000 meters on the chart. Once identified visually, the FAC(A) can use that known distance to judge other distances for CAS strikes or indirect fire corrections.

Threat Levels (defined)

High Threat: Defined as integrated air defense systems (IADS). This implies that the enemy has a radar guided SAM / AAA network that is tied in with early warning or search radars for cueing. Additionally, the enemy may have electronic warfare assets as well as fighter aircraft, tied in by a C³ system. In general, these are strategic type surface to air missiles, and heavy caliber radar guided AAA. On the low end of "high threat" SAMs, we may consider the SA-6 & Strait Flush fire control radar with the Long Track and Thin Skin radars for EW (early warning) cueing. The high threat scenario is the least likely situation that the FAC(A) will be required to work in. In this situation, the FAC(A) is extremely vulnerable. By definition, close air support requires at least local air superiority. Before effective CAS can occur, interdiction strikes will have to disable any integrated enemy air defense systems. Weather plays a significant role in defining threat status. If the weather or visibility forces the FAC(A) down into the heart of the envelope of less sophisticated threat systems, the FAC(A) can find himself in a "high threat" situation. If the troops on the ground need support, the FAC(A) must find a way to provide that support, regardless of the threat condition.

Medium Threat: A medium threat CAS scenario can be difficult to quantify. While medium threat is generally not regarded as "integrated" air defense, there may be lethal radar guided threat systems in the vicinity of the target area. Medium threat can generally be defined as mobile threat systems with autonomous radar acquisition and guidance, or those optically guided systems that possess sophisticated IR acquisition capability and relatively long range. Additionally, heavy caliber AAA with autonomous radar or optical guidance not tied into a C³ system will be considered "medium threat". Examples of each are listed below:

Radar Guided

SA-6 (without EW cueing)
SA-8
Crotale
Rapier
Roland
S-60 (with Flapwheel radar)

Optical / IR Guided

SA-13
SA-9
2S6

Low Threat: Low threat CAS is defined by a relatively permissive environment. Systems such as shoulder fired IR SAMS, light air defense artillery, and small arms fall in the low threat category. These threats can be easily avoided by over flying them above their maximum engagement altitude. This is contingent upon good weather that allows visibility in the target area at a safe altitude. Below 12,000 to 15,000 feet AGL, the FAC(A) may be vulnerable to some of the less sophisticated threat systems. Typically, the FAC(A) can safely operate above 12,000 to 15,000 feet or so in a low threat situation. This is the scenario in which the FAC(A) will be most effective. He will have the most flexibility in the conduct of his mission. Low threat can quickly change to medium, however, with the introduction of a single SA-8 type threat. The FAC(A) can never assume that he can orbit overhead the battlefield with impunity. He must always be on the alert for a change in target area threat status.

FAC(A) Escort

The FAC(A) must always be prepared to carry out his assigned mission alone. There are situations in which the FAC(A) may have the luxury of an escort aircraft to provide additional support for the mission. MAWTS suggests that this escort aircraft be a single seat Hornet, since sending two F/A-18Ds would reduce the number of potential FAC(A) platforms in the theater. Assigning the escort mission to a single-seat platform would free up the other "D" to be used by the ACE on another FAC(A) mission. While this certainly makes sense, we never train with our single seat brethren for this mission. This fact goes against the one of the basic tenants of warfare, "to train like we expect to fight." Therefore, we must create a set of standards that an escort must be able to perform if he is to enhance both the capability and the survivability of the FAC(A). These tactics will be discussed later in each of the different threat scenarios.

Escort Aircraft Configuration

The following is the optimal load out for the FAC(A) escort by store station:

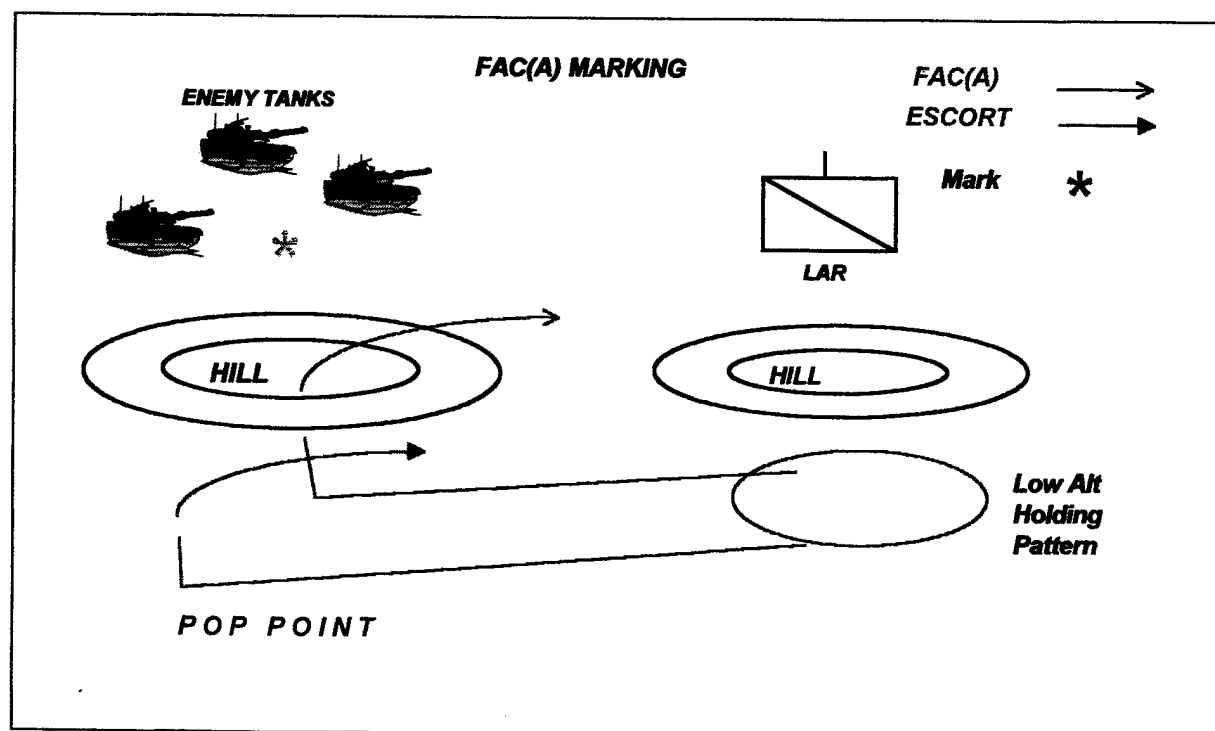
- 1) AIM-9
- 2) HARM
- 3) 330-gallon drop tank
- 4) AMRAAM (AIM-7 if not available) / possible TFLIR for night operations
- 5) 2 x Mk-82 or 2 x Mk-20 Rockeye
- 6) AMRAAM (AIM-7 if not available) / possible NAV FLIR for night operations
- 7) 330-gallon drop tank
- 8) 2 x LAU-10 w/ 5 inch HE ZUNI rockets (8 total)
- 9) AIM-9

Stations 1 and 9 are standard. The HARM provides the escort with the ability to attack any radar guided system that may be a threat to the FAC(A) and CAS aircraft. The HARM should have programmed MNT or MME threat classes specific to the enemy order of battle. The HARM will probably be employed in Target Of Opportunity (TOO) mode or in Self Protect (SP) mode for fast response to threat radars. Fuel tanks on 3 and 7 match the FAC(A)'s configuration to ensure similar time on station. AIM-120s on 4 and 6 would give the escort significant capability if the FAC(A) was challenged by enemy aircraft. "Launch and leave" tactics would probably be required for any significant air to air threat. The missiles would also provide the escort the ability to defend the Marine infantry in the event that the enemy had CAS assets. Station 5 with two bombs or Rockeye gives the FAC(A) the option of using the escort as a CAS bird in the event that no other CAS aircraft are on station. HE Zuni rockets on station 8 are arguably the best suppression ordnance for the escort, since they are deadly accurate, quickly employed, and provide sufficient punch to neutralize most surface to air threats. The Zuni could easily disable a light AAA system or an SA-8 or SA-9 vehicle. There may be some consideration to carrying 5-inch WP rockets instead of HE to give the FAC(A) additional marking rounds. This should not be necessary if the FAC(A) is carrying his standard load of 16 rockets. The HE would provide more flexibility and eliminate the chance that the escort might suppress a target with WP which might be confused with the FAC(A)'s mark. 500 rounds of 20-millimeter are assumed. Stations 4 and 6 could be loaded with TFLIR or NAVFLIR for night operations, if required.

High Threat Tactics

In a high threat CAS scenario, if at all possible, the FAC(A) should attempt to bring fires to bare on the enemy's integrated air defenses to lessen the threat to friendly air assets. This will require the FAC(A) to advise the DASC of the enemy anti-air situation in the target area, and request assets to neutralize those threat systems. As a general rule, the FAC(A) should attempt to work at as high an altitude as possible to accomplish the mission. Logic assumes that it may be easier to fend off a single SA-6 at high altitude, than to fly low in heart of the envelope of all the man pads, AAA, and small arms. If the scenario dictates, however, the FAC(A) may need use low altitude tactics to ingress into the threat sector to avoid being acquired by enemy radar systems or to work under the weather. This will make the FAC(A) vulnerable to unsophisticated target area threats such as shoulder fired SAM's, light AAA, and small arms. For this reason, he must remain terrain masked until it is necessary to acquire targets, mark them, and control CAS assets on the enemy. The most survivable low altitude mark delivery profiles for the FAC(A) may be to laze with the LTD/R from a standoff position, or to loft the WP Zuni rocket toward the target from a standoff position. Pilots must be familiar with rocket loft tables. Another possible delivery may be a standard Marine 30/30 pop attack to mark the target. Low altitude FAC(A) is a very risky proposition. Other options may be more prudent. If the ground FAC is able to control the mission and mark the target with indirect fire assets, this may preclude the FAC(A) from ever entering the threat sector. Cobra and Huey FAC(A)s on station may also be a better option to control CAS in a high threat scenario. Helicopter FAC(A) tactics change little with regard to what we consider high, medium, and low threat scenarios since they are always vulnerable to the most basic enemy weapon systems. They will always fly at low altitude and use the terrain to mask themselves.

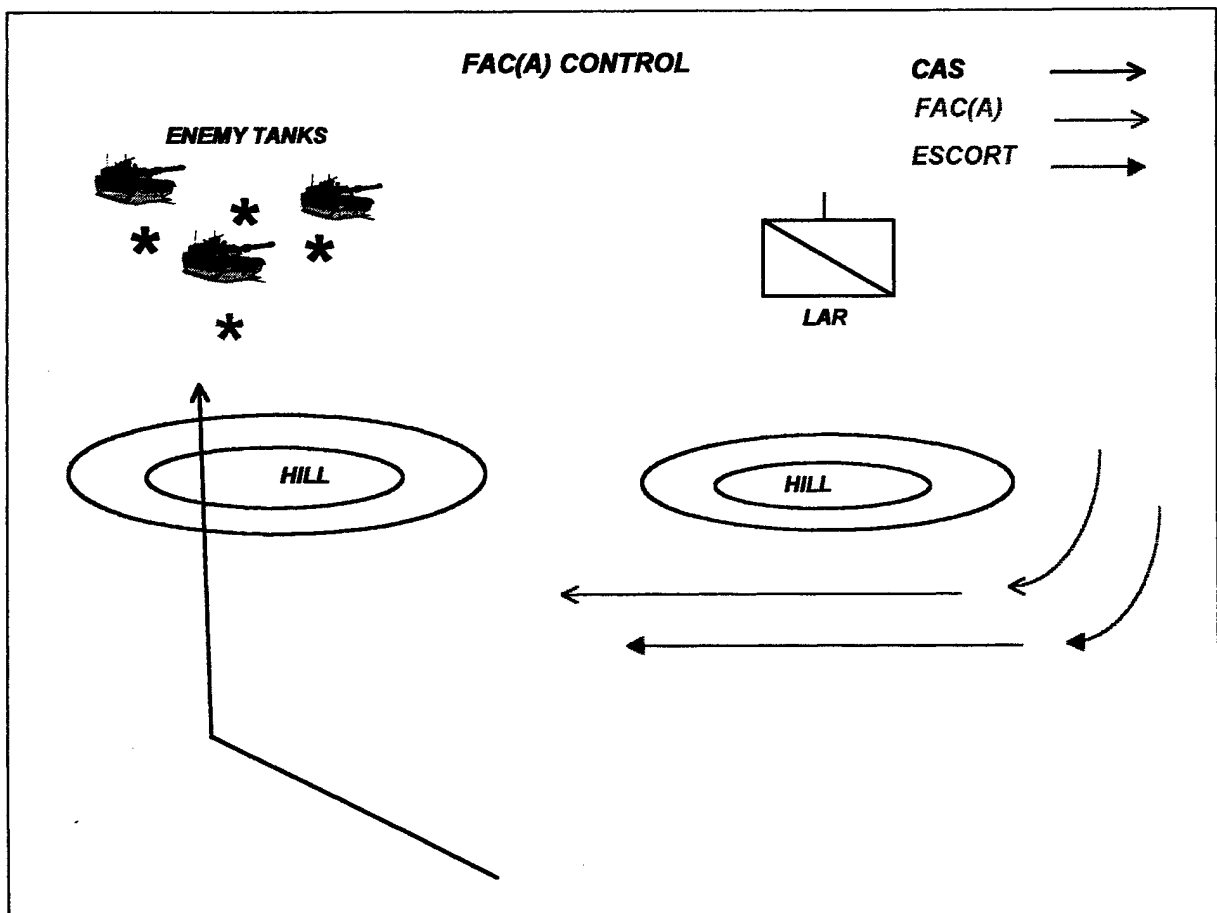
The diagram below illustrates a typical high threat, low altitude game plan.



High Threat Tactics

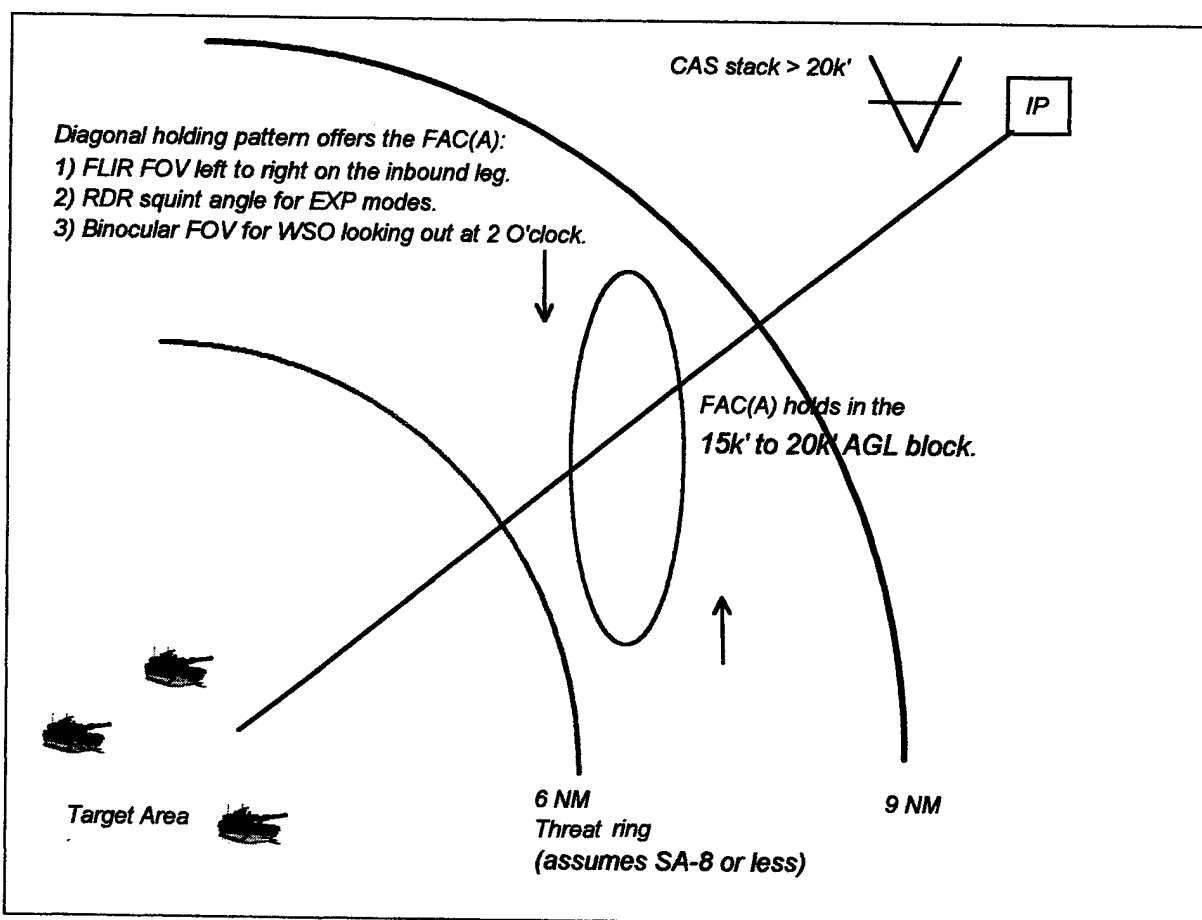
Notice in the previous diagram that the FAC(A) escort maintains "fighter wing" formation while in the holding pattern. As the FAC(A) begins his marking run, the Escort takes separation to get into position to provide support to the FAC(A) while he is exposed and vulnerable to enemy surface to air threats. During the FAC(A)'s marking run, he will be vulnerable to AAA, man pads, and small arms fire. From his perch high and behind the FAC(A), the Escort can quickly employ his 5-inch HE Zuni rockets at any of these pop up threat systems. As pictured, the Escort should attempt to avoid the target area threats as much as possible by not penetrating the threat sector with the FAC(A). Once the FAC(A) is clear, the Escort should immediately re-mask behind the terrain and rejoin the FAC(A) back behind the hill. The Escort should have his HARM page up on his left DDI. Ideally, he should run in TOO mode with an MME or MNT threat class selected that is specific to the enemy order of battle for that geographic location. If at any time during the mission, the Escort picks up a threat system, he should be able to "hand off" and engage the target with the HARM. HARM ORIDE may be unboxed to allow rapid response to pop up threats, but this is not recommended by HARM experts.

Now that the target has been marked, the FAC(A) must position himself to control the CAS aircraft. The diagram below shows the FAC(A) positioning himself just above the terrain enough to see his mark and adjust the CAS aircraft onto the target. The Escort should be in fighter wing stepped up high off the FAC(A)'s wing in a position to look through the FAC(A) toward the target area.



Medium Threat Tactics

Most of the threat systems in the medium threat category can be over flown or avoided by lateral offset. The SA-8, for example, can be over flown above 18,000 to 20,000 feet. It can also be avoided laterally by 6 to 8 nautical miles or so. Since many of these threats are mobile, and can quickly appear in the target area, the FAC(A) should assume at least medium threat every time he enters a new working area! The FAC(A)'s initial game plan should be built around medium threat tactics. As such, the FAC(A) should run the CAS aircraft at medium to high altitude from the CP to IP to the target. IP to target is acceptable if the IP is far enough away to avoid the threat, laterally. A CAS ingress above 20,000 feet and descending no lower than 12,000 feet should avoid / minimize exposure to most medium threat systems. The FAC(A) should position himself in the 15,000 to 20,000 foot block, and hold 6 to 9 miles away from the target area. The 6 to 9 mile gouge is a good "rule of thumb" for FAC(A) holding, as it represents about one minute of flight time. From this range the FAC(A) can be in position to deliver a mark in around 30 to 60 seconds from any point in his holding pattern. From these ranges, aircraft sensors can be effective in locating targets. The diagram below shows a standard holding pattern that a FAC(A) can use for most situations. It provides a safe haven from most low and medium threat systems, yet provides visual and sensor field of view into the target area in good weather conditions. In poor weather conditions and for acquisition of individual small targets, the FAC(A) may need to leave his perch and penetrate the threat sector. Obviously, this must be done rapidly at tactical airspeeds with consideration for preemptive expendables.



Medium Threat Tactics

The WSO should manage the aircraft systems while the FAC(A) is in the target area. NAV MASTER MODE should be used by the FAC(A) 90 percent of the time to maximize sensor flexibility! "SENSORS" should be boxed on the HSI to correlate TFLIR and radar fields of regard with the moving map. With OFP 09C and higher, GEO REFs should be used to maintain SA on the control points in the area. Prior to showing up on station, the FAC(A) crew should have chosen control points that support the scheme of maneuver. Those points should be entered in the system as GEO REFs for situational awareness on the HSI. NAV MASTER MODE allows full up A/A radar capability with HAFU symbols, and quick access to A/G radar by using the "AIR" and "SURF" options on the ATTACK page. The TFLIR defaults to the A/G format in NAV MASTER MODE, allowing the FAC(A) to accomplish numerous tasks in the target area. The crew should only need to select A/G MASTER MODE during TAMPS checks prior to mark delivery. A/A MASTER MODE can easily be selected by the pilot if required via the WEAPON SELECT switch.

The TFLIR and the binoculars should be used to assist in pin pointing the target location, while allowing the FAC(A) some stand off. If the FAC(A) must enter the target area to identify the target, he should quickly enter and exit the threat sector. On his run in, the WSO should "NAV DESG" the target if he has the coordinates to type in. For targets of opportunity, the FAC(A) pilot should "HUD designate" the target. Either method will give the FLIR cueing to allow the FAC(A) WSO further refinement. The HUD designation should be done out at range to allow a shallow dive angle of 10 to 20 degrees maximum. The FAC(A) pilot should not make the mistake of pressing in to close to the target and doing a steep dive, losing altitude in the threat sector just for the sake of getting a HUD designation. If the pilot is not able to accomplish the designation of the target via the HUD, a "Mark" can be dropped if the target is over flown. This may also help to get the TFLIR on target. By getting the TFLIR on the target, with its 4X power magnification, should allow the FAC(A) to keep SA on the target area until it has to be marked for the CAS run. This habit pattern carries over to night tactics.

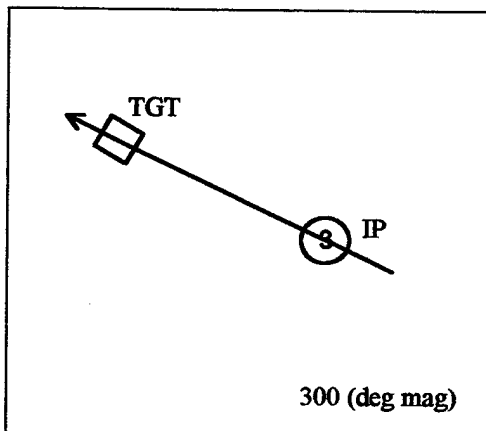
Once the target is identified and designated, the FAC(A) should return to his holding pattern, and begin working up the 9 LINE brief. There are two methods of using the system to aid in building the brief quickly. The goal of both methods is compute LINES TWO and THREE, the IP to target Heading and Distance:

First Method: This method is used when the FAC(A) has the grid to the target, whether he determined the grid himself or it was provided by some outside agency. To borrow from HARM terminology, it is referred to as the "Pre-Briefed Method." Prior to takeoff, the WSO should go to the DATA page of the HSI and select any waypoint (not already an OAP), then select pushtile 5 "UFC." On the UFC, the WSO selects offset "O/S" then range "RG." The system default for the range of the offset is in feet. The WSO colonizes nautical miles "NM" on the UFC, and types in "0.0 <enter>." This will change all of the waypoints and marks from a default offset range in *feet* to *nautical miles*. Once airborne, when the WSO is required to build a 9 LINE, he simply types the grid to the target in the offset of the IP. The offset data on the lower half of the HSI will be displayed in *degrees true & nautical miles*. The WSO converts true to magnetic by looking at the Mag Var on the FAC(A) 9 LINE Card, and recording the value on LINE TWO. He then takes the nautical mile information from the HSI and records it on LINE THREE. The elevation of the target should be taken from the 1 : 50,000 chart. The remainder of the 9 LINE is then easily completed.

Medium Threat Tactics

Second Method: The second method is used for targets of opportunity, and is referred to as the "TOO Method." The WSO should always have steering selected to the IP that he intends to use for the next CAS mission. Once a target is acquired and designated by any method, the WSO selects "UPDT...DSG" on the HSI at pushtile 7. The system will display the *true bearing and range in nautical miles* from the selected waypoint (the IP), to the target (the designation) on the top of the HSI. The WSO then records that information on LINES TWO and THREE of the 9 LINE as he did in the first method. Once this is complete, he must select "REJ", to reject the update. If the WSO accidentally accepts the update, the system will slew the location of the IP to the designation. This could obviously cause a huge error in the INS. If this happens, the WSO simply selects "UPDT" then "CANCEL" (pushtile 3) to cancel the last update. The INS will then return to its previous status. The WSO may then choose to drop a "Mark" on the designation to record the coordinates. The coordinates should be verified on a 1 : 50,000 chart before being recorded in LINE SIX.

The HSI should be set up the same way with either method for positional reference. The diamond represents the target location, and the OAP / GEO REF symbol represents the IP. The WSO should take the COURSE LINE and run the tail of the needle of through the IP symbol. This will display the IP to target run in line, and also indicate the magnetic bearing from IP to target. This is another way to use the system to obtain and verify LINE TWO for the 9 LINE brief.



Medium Threat Tactics Narrative

The following narrative demonstrates a typical FAC(A) control of a CAS section in a medium threat scenario running from IP to target (all altitudes in AGL):

The FAC(A), Bat 61, is tasked by the TACP to investigate enemy activity along a major avenue of approach into friendly territory that is obscured from the TACP's view by terrain. Based on the geometry of the target area, the FAC(A) decides to use IP Ford for routing of CAS aircraft, should the need arise. The WSO selects waypoint 5 on the HSI (IP Ford). The crew checks the 1 : 50,000 chart, and agrees that the area to be reconnoitered is at 2 o'clock for about 15 miles. The FAC(A) pilot proceeds toward the area above 15,000 feet and bunts the nose of the aircraft to throw a HUD designation in the general vicinity of the road in the distance where he thinks he sees some dust blowing up. This provides cueing for the TFLIR, and the WSO begins to search along the road with the TFLIR as the pilot visually scans the area.

Mi-24D helicopters have been reported operating near the FEBA, so the WSO has the radar set up in 140/6BR/20-40NM/MED to scan the A/A picture at low altitude. *[This short range radar set should be used most of the time by the FAC(A) to keep SA in the operating area on both friendly and enemy aircraft. It can be particularly useful both night and day to help the FAC(A) find the CAS aircraft after the target has been marked. At no time, however, should the FAC(A) lock up any friendly aircraft. LTWS information is more than adequate for keeping SA high. Place the cursors over the trackfile information and actuate the TDC to make an L&S if one is desired. Don't use the UNDSG button to make an L&S. To do so will break any target designations that exist.]*

As the FAC(A) gets closer, the pilot confirms that the dust clouds are coming from the avenue of approach, indicating that there may be possible vehicles moving on the road. The WSO, satisfied that the A/A picture is clear, selects GMT mode of the radar, and continues to scan the road with the FLIR. The WSO notices GMT hits on the radar in the vicinity of the designation, and slews the radar cursors to the center of mass of the hits. He then transitions to the FLIR video, and confirms tanks and armored personnel carriers on the road moving toward friendlies.

The pilot offsets the aircraft away from the vehicles, and maintains his altitude sanctuary to avoid any possible surface to air threats that the enemy vehicles may have. The WSO drops Mark 1 on the designation, and retrieves the grid from the system. He records the grid on a blank FAC(A) 9 LINE card on LINE SIX after confirming it on the 1 : 50,000 *[remember that the grid from system is only as good as the INS drift at the instant that the mark was dropped]*. The WSO then advises the TACP of the situation, and confirms that there are no friendly units at those coordinates. The Air Officer clears Bat 61 to engage the vehicles with a section of CAS, Nightmare 33, that has just checked in at CP Honda, loaded with 6 Rockeye each. The WSO selects "UPDT...DSG" on the HSI, and records the IP to target range and bearing, then rejects the data. After converting the bearing to degrees magnetic, he records the data on the 9 LINE card on LINES TWO and THREE. LINE FOUR, elevation is determined by map spot on the 1 : 50,000, 400 meters in this case. *[400 meters x 3 = 1200 ; 1200 + 120 (10 % of 1200) = 1320 feet. This is a quick way to convert meters off of the chart to feet (approximately). The WSO could also keep small conversion table handy on his knee board.]* The rest of the 9 LINE is quickly filled out and read to Nightmare 33 when he is ready to copy. The WSO should dial in the COURSE LINE to provide IP to target reference on the HSI by running the tail of the needle through the IP as shown on page 140.

Medium Threat Tactics

Once the 9 LINE and the TOT are successfully passed to the Nightmare flight, the FAC(A) should pass any relevant "amplifying remarks" to the strikers. After passing the TOT, the FAC(A) has about 2 to 4 minutes to pass these remarks. As a general rule of thumb, the FAC(A) should pass a TOT 6 minutes in the future for targets requiring coordination with other supporting arms. For targets not requiring coordination, 4 minutes should suffice. When coming up with the TOT, the FAC(A) should just look at the running clock, round up to the next whole minute, and add 4 or 6 minutes. Obviously, if the situation dictates, the target may need to be serviced ASAP. CP to IP to target distance must also be considered when passing the TOT (assume 8 miles per minute - 480 knots). Prior to passing the amplifying remarks, FAC(A) should ask the CAS lead "advise when ready for amplifying remarks" to give him time to put the data in their systems.

Amplifying remarks example:

"Nightmare 33, your targets lie along a major north/south gravel road. The lead tank platoon is moving south toward friendlies and crossing the 17 Northing line now. The tanks are kicking up a lot of dust. A company of wheeled armored personnel carriers are about 500 meters in trail. The tanks are your target. The FAC(A) will put the mark 200 to 300 meters south, in the path of the lead elements. The weather is clear in the target area. There is a ZSU-23-4 two clicks east; artillery will provide continuous suppression; max ord is 8000 feet. The FAC will be rolling in from Base +13 (18,000 feet for our scenario). Your final attack heading is 300 to 360."

The FAC(A) may also want to recommend an attack profile if he thinks that the target should be prosecuted in a particular way based on geometry, threat, weather, etc. Since JCAS, unfortunately, does not address this topic specifically, the FAC(A) may need to come out in plain language and request, "Nickel, I want you to come in 30 second lead trail; I will give dash two a correction from lead's hits." This will probably not be necessary when working with Marine aircraft, but many USAF tactics are built around section attacks. Remember, a 30 second lead/trail attack offers the FAC(A) twice the chance to have effect on target if the lead misidentifies or fails to acquire the target.

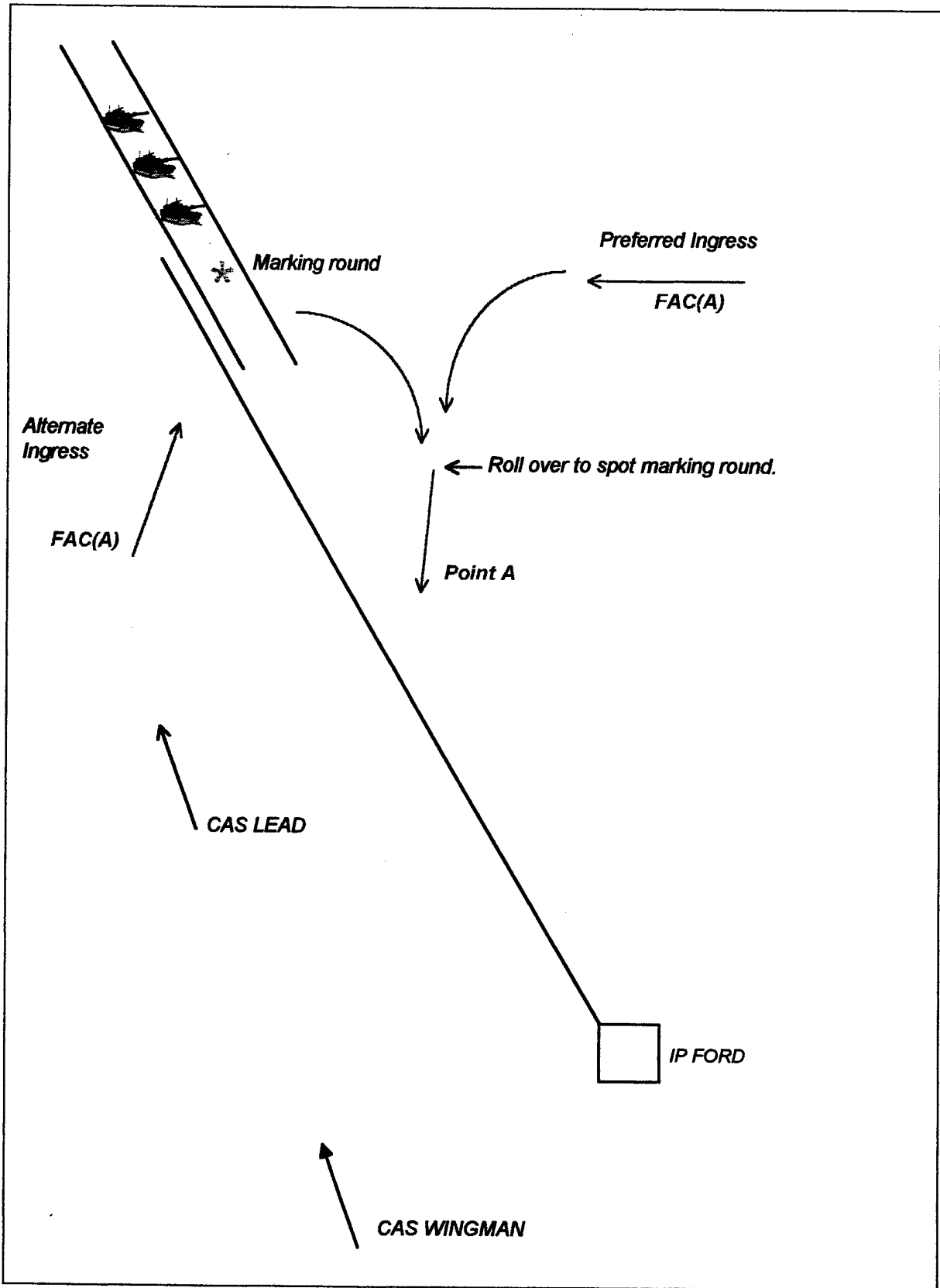
The FAC(A) pilot maintains an orbit in the 15,000 to 20,000 foot block and offset 6 to 9 miles from the target area. He pushes from his pattern at about time TOT minus 1+30. That works out to about 1+00 in route to put the mark down 30 seconds prior. The WSO slews the FLIR diamond a couple hundred meters in front of the tanks. The pilot should run through a quick "TAMPS" to get prepared to shoot the marking rocket. The WSO calls "FAC is in from the east." The sketch on page 144 shows how the FAC(A) would ingress into the target area to deliver the marking rocket. The "preferred" ingress route is shown from the east. Coming in from this aspect offers the FAC(A) several advantages. First, it provides some deception because the strikers will come in from the opposite side (from the west). Second, the FAC(A) will keep the entire picture in front of him on the way in; both the target area and the strikers. As mentioned previously, the short range radar set will help to keep SA on the CAS birds. After the pilot completes the TAMPS checklist and the WSO completes the final slew of the FLIR on the aimpoint, the radar will be in A/G - AGR mode. By hitting "AIR" on the ATTACK display at pushtile 3, the WSO can get raw hits on the strikers on the scope (no HAFUs in A/G). This should be an "unconscious" act by the WSO. The WSO can begin scanning the sky for the strikers prior to the mark delivery using the raw hits a reference to cue his eyeballs ("preferred" ingress method only). This habit pattern is critical at night where visual acquisition is challenging to say the least. The third advantage of the "preferred" ingress is that the turn to outbound is only 70 to 90 degrees vice 180 to 210 degrees for the "alternate" ingress option. If it is not necessary to "lead" strikers into the target area, the "preferred" method will lead to better control.

Medium Threat Tactics

In the chute, the pilot may choose to kick out some preemptive chaff, but he should only dispense flares if he thinks he is targeted to avoid highlighting the aircraft unnecessarily. Once the mark is away, the pilot will start a climbing turn back toward the IP to parallel the IP to target 9 line. Once established outbound, the pilot may need roll the aircraft over on its back momentarily to allow the WSO to see the impact of the marking round to make a correction. The WSO should have made note of his roll in direction to aid in making a quick and accurate correction from the mark. He should have anticipated, for example, that he would be looking back from southeast to northwest when the pilot executed the roll over maneuver. "From the mark, northwest 300."

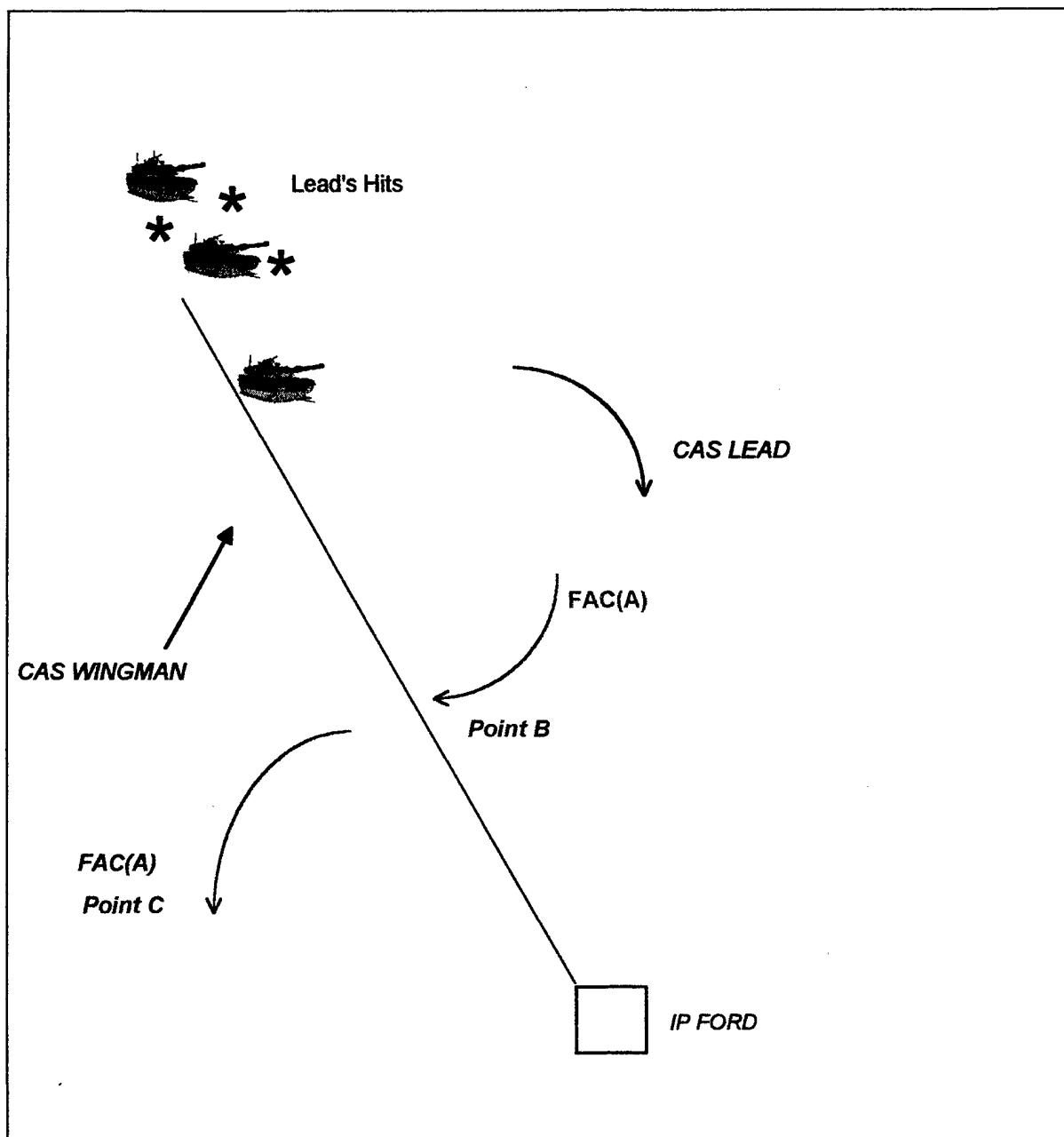
When the pilot rolls the jet back upright, he should be pointing back toward the IP, ideally about 20 degrees or so less than parallel to outbound. Using either the "preferred" or the "alternate" ingress method, he should end up at the same point in space at "Point A" in the sketch on page 144. This should put the crew in perfect position to visually acquire the lead CAS bird at 10 or 2 o'clock, and the dash two bird should be off the nose for 3 to 4 miles assuming a 30 second trail. At "Point A" the target area should be at the 4 or 8 o'clock position. A quick glance at the radar display by the WSO may aid in acquisition. Coming off target the pilot should unconsciously select A/A by selecting AIM-9 on the WEAPON SELECT switch. Once pointed back toward the IP, the AIM-9 140/6BR/20/MED, "super search" set may get a raw hit on the lead at 30 to 40 right on the scope, and the dash two should be right off the nose for 4 miles if the timing of the attack is good.

Ideally, the WSO will pick up the lead aircraft visually and control him all the way in. Both pilot and WSO should be scanning for the lead. If the pilot sees the lead first he should simply say over the ICS "Right 2 o'clock, level, lead looks good." The WSO should then clear the lead "hot" based on the pilot's assessment. *[The WSO should maintain the communications outside the cockpit for continuity and voice recognition since he has been doing all of the talking up to that point. If the pilot had been running the communications, then the same applies. The WSO need not "see" the lead or wing man if the pilot verifies that the striker has the proper target. This assumes that the pilot and WSO are both experienced. The crew should not waste time talking the each other's eyes on to the strikers if both crewmen are qualified FAC(A)s.]* The pilot should begin scanning forward for dash two, while the WSO controls the lead and spots his hits. The WSO comes up with a correction from lead's hits, and passes it to dash two. "Nightmare 34, from lead's hits, north 200." The same crew coordination applies for clearing the dash two "hot" with regard to visual acquisition; either crewman acquires the striker visually and verifies that he "looks good," then the crewman running the communications clears him "hot" over the radio.



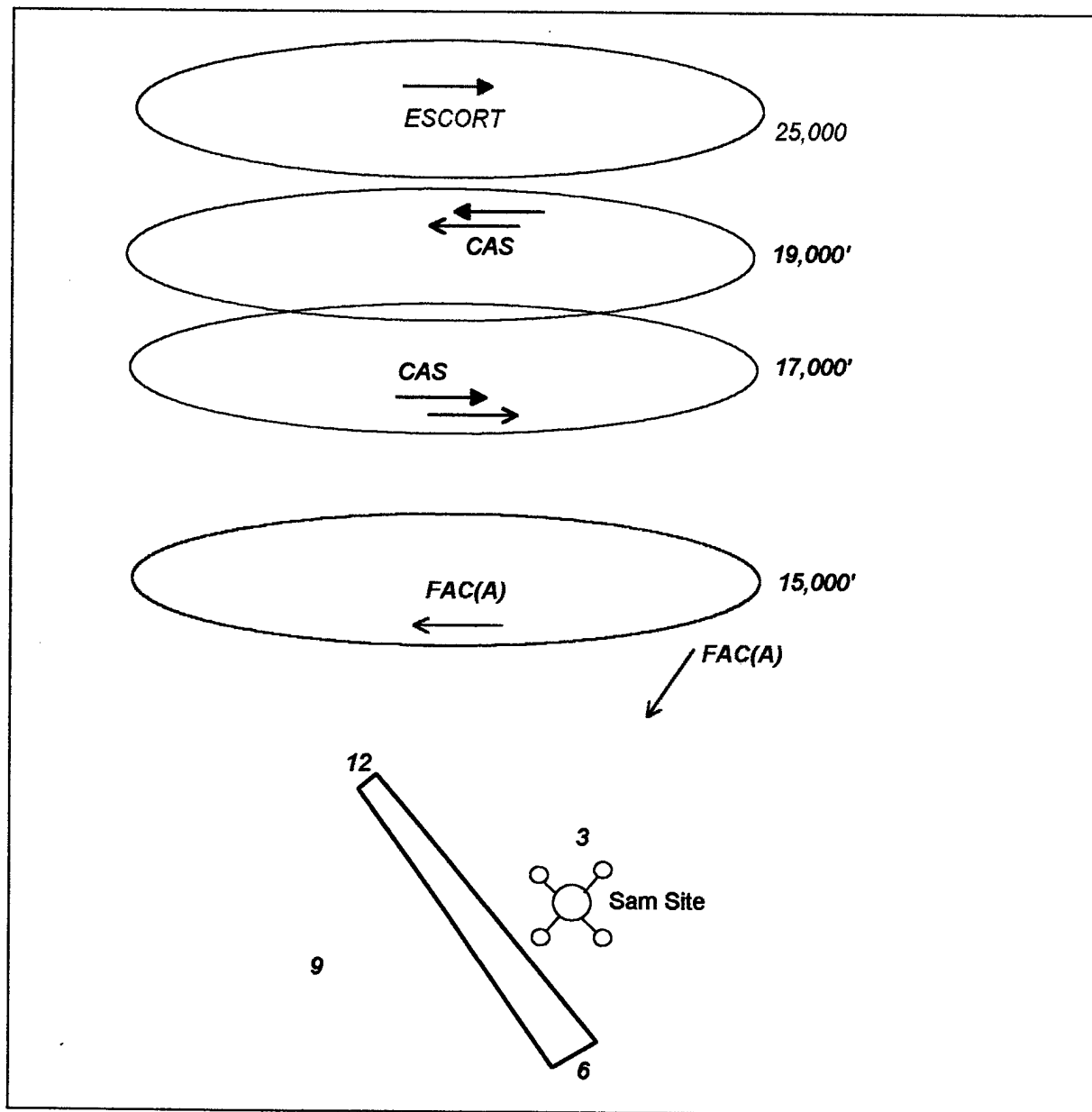
Medium Threat Tactics

The pilot continues to position the aircraft to keep the target area and the strikers in sight as the attack continues. With the dash two striker in sight, he should continue his turn as in a "stern conversion." This should result in the target area at the 3 or 9 o'clock position with dash two at 2 or 10 o'clock (Point B). Once dash two's bombs have been spotted and his "six" has been cleared by the FAC(A), the pilot should turn back the shortest distance toward the safe haven of his original holding pattern. The geometry is depicted below.



Low Threat Tactics

The FAC(A) should always assume that an unfamiliar target area has medium threat systems and execute CP - IP - target or IP - target tactics accordingly. As the FAC(A) becomes confident that no medium threats are present in the target area, he can choose to transition to low threat tactics. Generally, low threat tactics are defined by an overhead "wagon wheel" scenario where the FAC(A) stacks the strikers over the target area above the FAC(A)'s altitude. The FAC(A) may have to mark the target area on the first pass, but as the strikers gain familiarity with the terrain, the FAC(A) may be able to simply provide "talk-ons" for subsequent attacks. The sketch below depicts a typical "wagon wheel." The altitudes may be higher or lower depending on threats and weather.



Low Threat Tactics

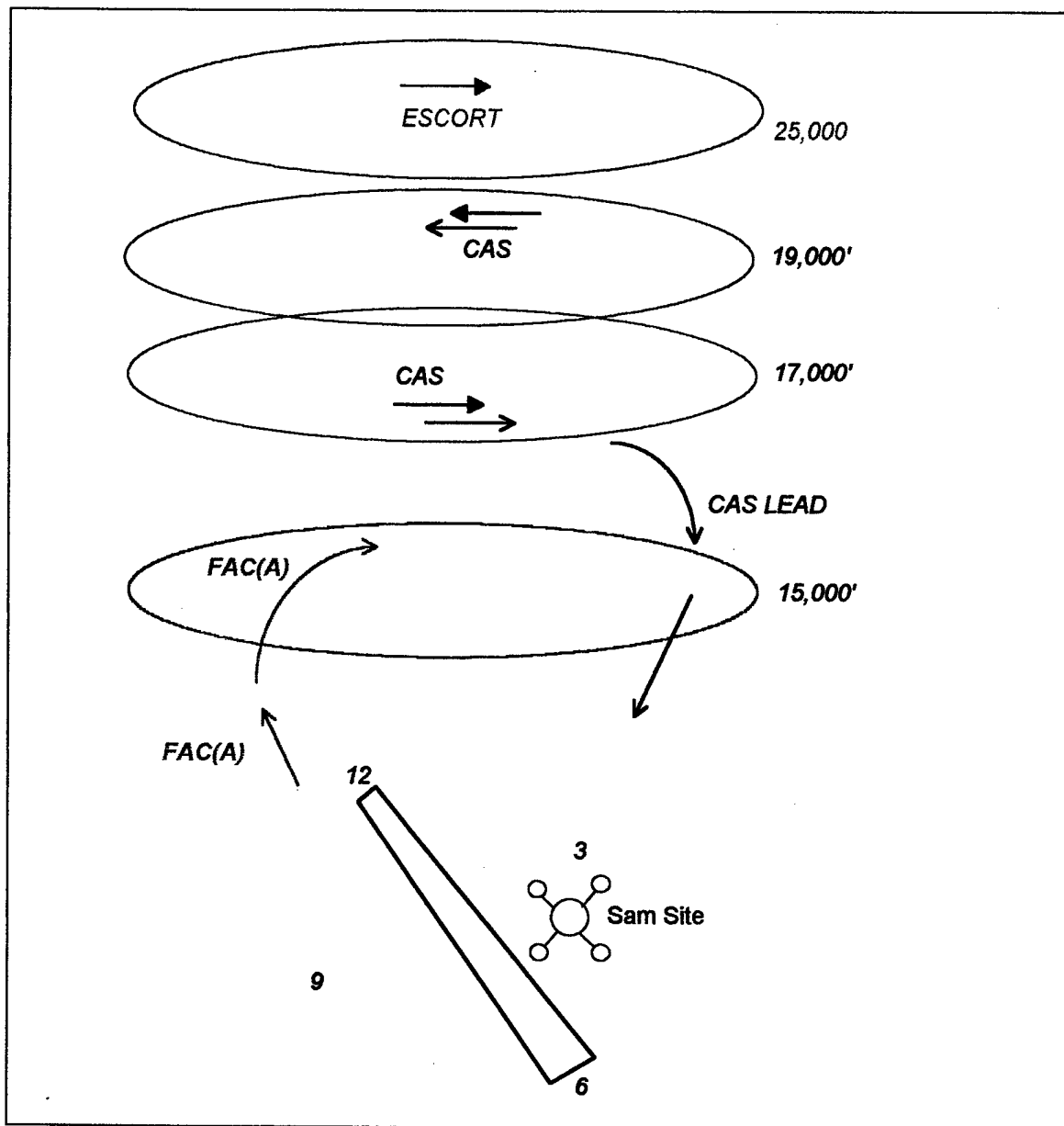
The sketch on page 146 shows the FAC(A) using CAS to take out a SAM site at an airfield that the MAGTF is trying to capture (the radar has been disabled). Notice that the FAC(A) places himself at the bottom of the "stack" with the strikers above. The FAC(A) should always make right hand turns in the wagon wheel because this gives the TFLIR a clear field of view looking under the fuselage from left to right. Left hand turns cause the TFLIR to be blocked by the wing fuel tank on stations 3. This habit pattern carries over to night tactics, and maximizes the use of all sensors in the target area. The strikers above can take up left or right hand flow, it should not make much difference to the FAC(A). Opposite flow allows the FAC(A) to see the strikers every 180 degrees of turn when they cross overhead, whereas "same way" flow keeps the FAC(A) in the same relative position from the strikers all the way around the circle. Sometimes with same way flow the FAC(A) can find the CAS aircraft are difficult to see because they may get stuck in lag behind him. By controlling the direction that the strikers roll in from, the FAC(A) can avoid having to scan wildly around all 360 degrees of the circle as they roll in for their attack. The FAC(A) should establish a final attack cone where he wants the CAS to come in from. Usually a 30 to 60 degree cone works well in defining how the flow will work in the target area. When the target area has a linear feature in the vicinity, it can be useful to establish clock codes for reference as indicated on the diagram on page 146.

The FAC(A) should not have to use a 9LINE brief to get effect on target using the wagon wheel. He can bring the CAS birds into the wagon wheel immediately upon check in or initiate a wagon wheel as a method to re-attack a target after the strikers complete their first run from an IP. The following is a narrative of how the communications might go:

"Bat 61, Nightmare 33 checking in a CP Dodge as fragged at base plus one-four (base will be 5,000 feet for the scenario on page 146)." "Nightmare 33 proceed directly toward the target area at grid PG123456. Take up orbit at base plus one-two; I will be at base plus 10 and below. The weather is clear and the threat has been small arms only, but be alert for man pads. Advise me when you have the FAC(A) in sight." "Bat 61, Nightmare 35 checking in as fragged, 15 miles south of Dodge at base plus one-five. I copied grid PG123456." "Nightmare 35 proceed toward the target area and take up orbit at base plus one-four. Nightmare 33 is below you at base plus one-two, I'm working base plus 10 and below." "Bat 61, 33 has you in sight, I'm at your 2 o'clock high." "Bat 61 is visual, do you have the clover shaped SAM ring insight on the southeastern portion of the runway below." "33 is tally the SAM ring." "Nightmare 33, the radar has been destroyed and we will be taking out the TELs. The southern most leaf of the clover will be your target, 34 will hit the western leaf. I want final attack headings from 300 to 360; elevation is 150 feet. Expend all bombs on the first pass, then set up for guns at base plus 8 to take out the dismounts." "33 copies...34 copies" "The friendlies are 2 clicks south in the tree line, I will be hitting a vehicle one click north of your target with a single Mk-82...the FAC is in from the southeast. You are free to roll in with the FAC in sight." *[As the FAC(A) rolls in to mark, or to drop his bomb in this case, he knows that the strikers will be rolling in behind him from the southeast based on the final attack heading. The FAC(A) pilot must quickly position the jet to observe the lead striker by starting a climbing right hand turn back to his 15,000 foot perch (refer to page 148 sketch). It is up to the FAC(A) to de-conflict his flight path from that of the strikers as they roll in. In this scenario, the FAC(A) will remain above them as the strafe from 13,000 (base plus 8)]* "Nightmare 33 is in from the southeast with the FAC in sight, wings level." "Nightmare 33, cleared hot." "Nightmare 33, good hits, I'm at your 10 o'clock high." "Nightmare 34 is in from the southeast with the FAC in sight, wings level." "Nightmare 34, cleared hot..."

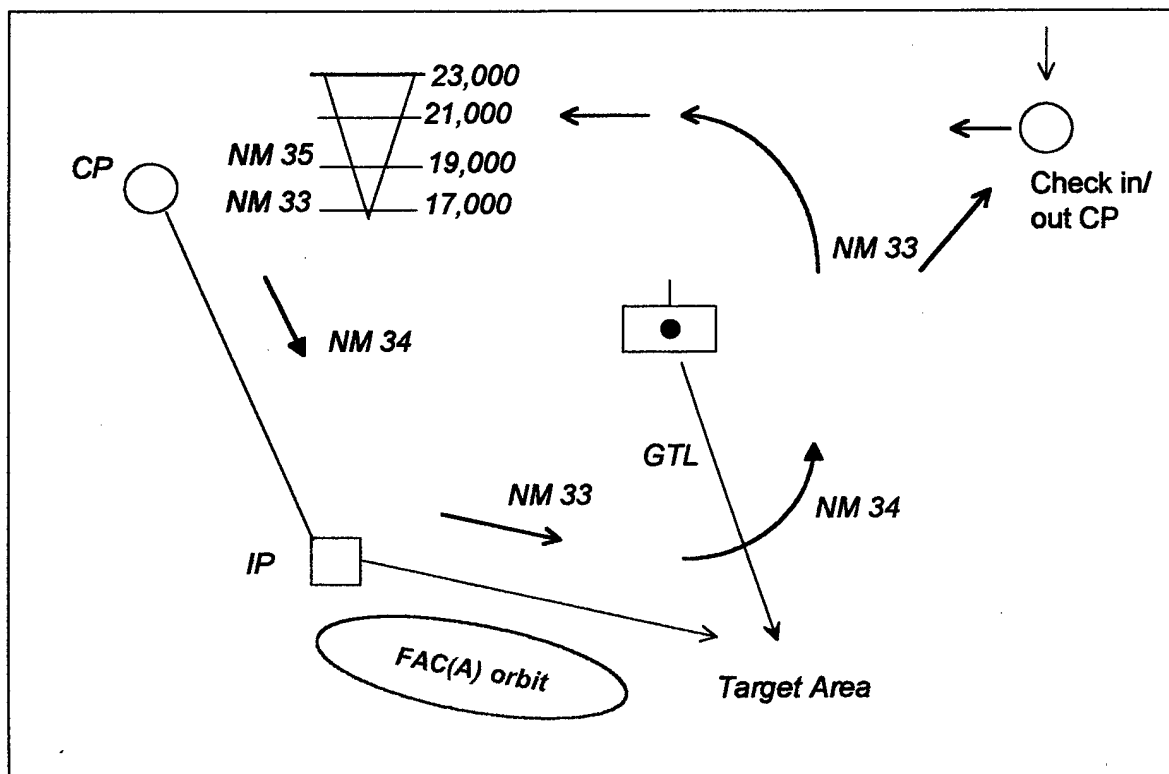
The FAC(A) would continue the scenario by working with the first set of fighters until they had expended their ordnance, then clear them from the area. The FAC(A) would then pick up with the next group of fighters in the same fashion. The pace of the attacks should be rapid and devastating. The FAC(A) may not need to mark targets for each run if strikers can see the target area well. Perhaps only the

first run of each group of fighters may need to be marked. The FAC(A) should not become oblivious to the threat level in the area when working the wagon wheel. The enemy may move in mobile air defense systems quickly. At night the enemy will have difficulty employing man pads and ZSU-23s against aircraft in the wagon wheel at the altitudes depicted. This allows the FAC(A) and the strikers to remain in visual contact with the target area with NVGs and keep FLIR sensors oriented on target aim points. Target detection and the accuracy of CAS engagements will be greatly enhanced using the wagon wheel. In the absence of radar guided threats the FAC(A) should consider using the wagon wheel for night close air support control. The FAC(A) should keep communications to a minimum and avoid lengthy "talk-ons." Remember, a good mark is worth a thousand words.



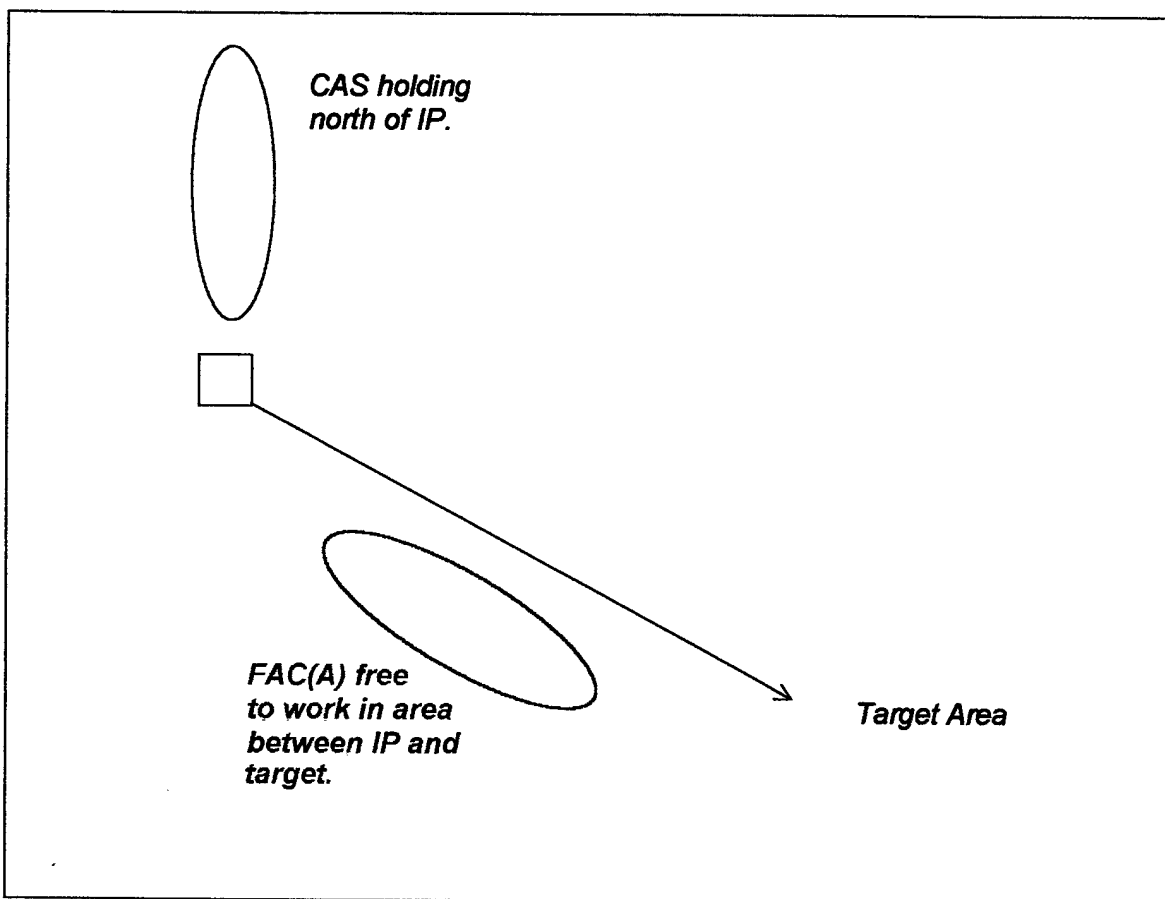
Forward Area Air Traffic Control

The FAC(A) must be able to manage the airspace in his vicinity to de-conflict the CAS aircraft from each other and from other supporting arms. The DASC will manage the large CAS stacks that support the overall MAGTF. There will be times when the FAC(A) will have to set up forward area CAS stacks to allow for multiple strikers to provide support in a relatively small area. Ideally, the DASC will send all the strikers forward to one "check in" CP to work for a particular FAC or FAC(A). From that CP the FAC(A) will take control of them and form a stack at separate control point that he controls. The "check in" CP cannot be used by the FAC(A) to stack since he has no definite way of knowing at what altitude that the DASC is sending strikers forward to that point. The diagram below shows how the FAC(A) would manage a stack at a single control point. Notice that the FAC(A) is using an IP ingress roughly parallel to the FLOT. This generally helps to de-conflict the strikers from the artillery gun target line (GTL) which is typically perpendicular to the FLOT. In the diagram, the strikers only cross the GTL near the target area where the trajectory of the artillery is at its lowest. In fact, staying above artillery fragmentation should be more of a concern than an air to air collision between an aircraft and a projectile. After leaving the CP CAS stack at 17,000 Nightmare 33 drops his bombs in the target area then egresses north and west to reposition in the stack at 21,000 to remain above Nightmare 35 at 19,000. For a new CAS section that might check in the FAC(A) could leave a spot open at 23,000 or higher.

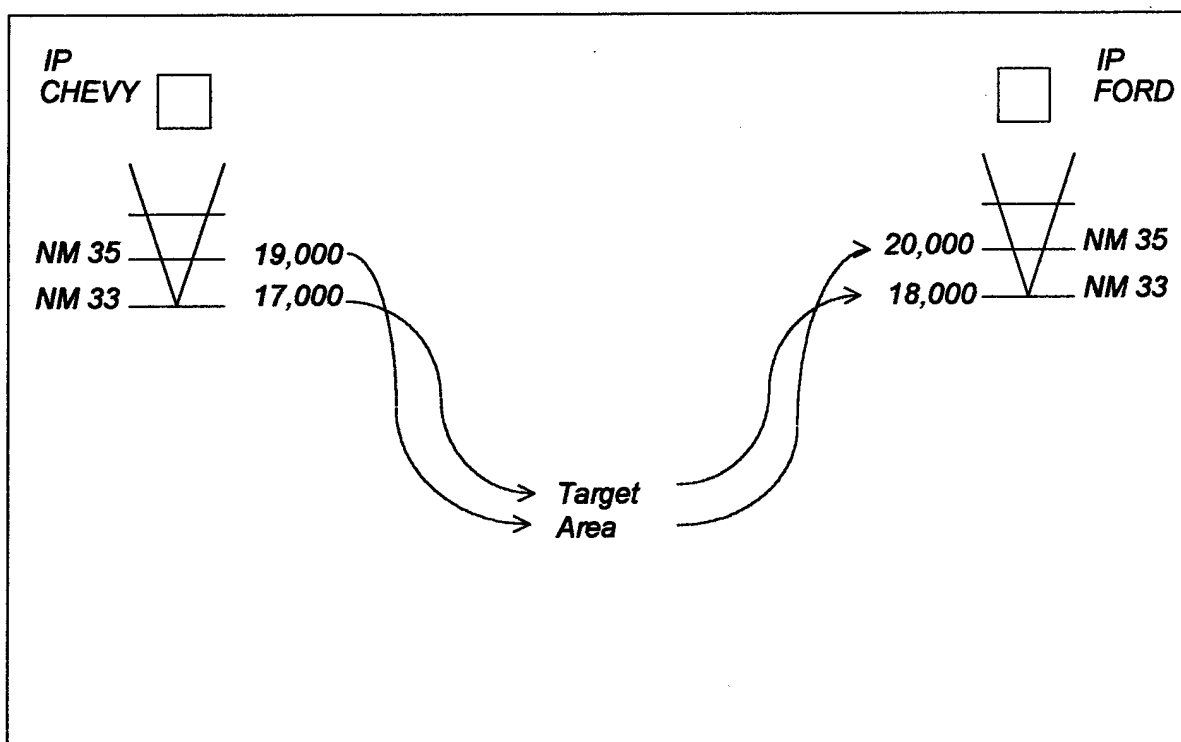


The FAC(A) should attempt to have each CAS section expend all of its bombs on one pass to achieve devastating effects on high payoff targets as opposed to making several runs into the target area dropping one or two bombs per pass. This should preclude the need to send a CAS section back into the stack for another run into the area, and Nightmare 33 could be routed out of the area by the FAC(A) through the check in/out CP. The Special Instructions in the ATO should account for the de-confliction of CAS aircraft inbound and outbound from the check in/out point. For example, the DASC may route all aircraft to the check in point at 27,000 and above while the FAC(A) sends CAS aircraft outbound at 26,000 and below. In the previous diagram, Nightmare 35 would be given a TOT no less than two minutes after Nightmare 33 to allow for de-confliction and time for the FAC(A) to reposition for control of Nightmare 35.

In a combat environment such as in Desert Storm, the distance between control points may be unreasonably far for CP - IP - target ingress. The FAC(A) may find that IP to target ingress is more practical. In this case, the FAC(A) may not want the strikers to maneuver in the area between the IP and the target to keep the strikers further away from the threat and to reduce airspace congestion in this area. In this case, the FAC(A) may give the strikers a restriction such as "hold north of Dodge at base plus one-four." This is depicted below.



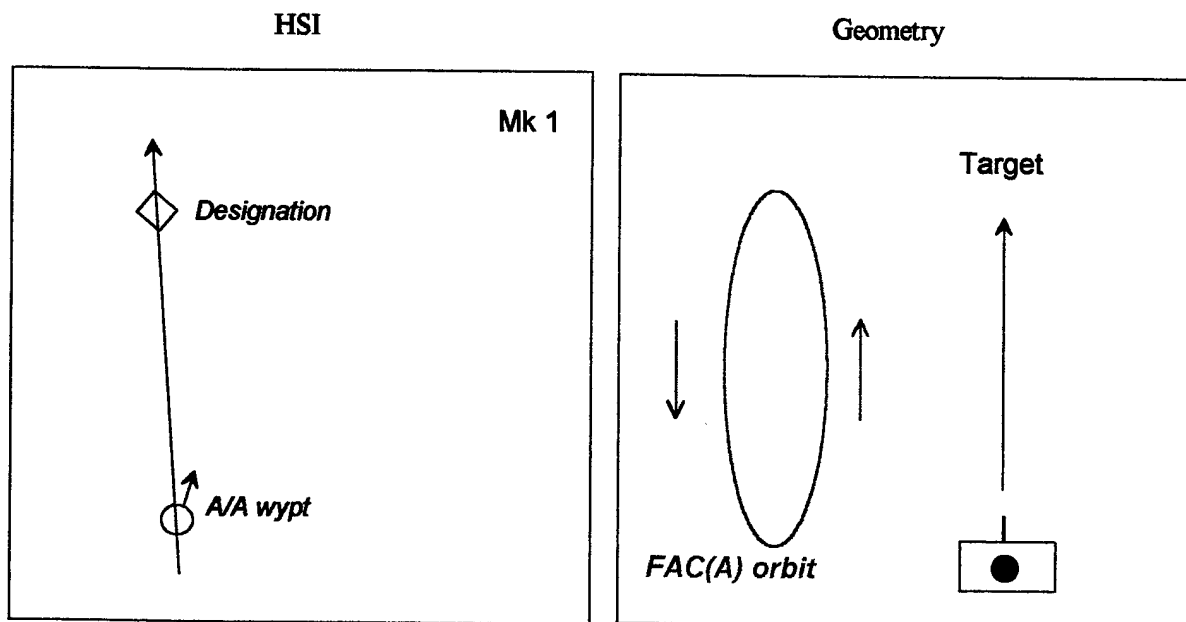
The FAC(A) may choose to use two control points to manage the airspace near the target area. This could be used if the strikers were going to make several runs into the target area. As stated before, it is best to get CAS aircraft into and out of the area quickly, dropping all of their bombs on the first pass. This may be followed by immediate re-attacks for strafing runs to take advantage of the 20/25 millimeter canons which were so effective during the Gulf War. Hornets and Harriers do not have great loiter capability, and must be cycled rapidly through the target area. In training, however, CAS aircraft may remain in the target area longer to get multiple practice runs during one sortie. This requires that the FAC(A) is prepared to control several sections. The diagram below shows how a two control points can be used for airspace coordination.



Notice that Nightmare 33 moves from the bottom of the western stack to the bottom of the eastern stack. Likewise, Nightmare 35 moves from top to top. This maintains the order of 33 then 35 on each successive run. As stated before, at least two minutes should be allowed between the TOTs of the two sections to allow for lateral deconfliction. The only potential conflict using this method of airspace control occurs when Nightmare 35 climbs through 33's altitude (18,000) to get to his assigned place in the eastern stack (20,000). This risk can be reduced in several ways. For example, the FAC(A) may require that all strikers hold north of the control points to allow more distance for 35 flight to climb to 20,000 feet after his attack. The FAC(A) may also choose to issue specific egress instructions such as "Nightmare 35, egress east, climb to base plus one-five (20,000) then north to hold at IP Ford, 33 flight is below you at base plus one-three (18,000)."

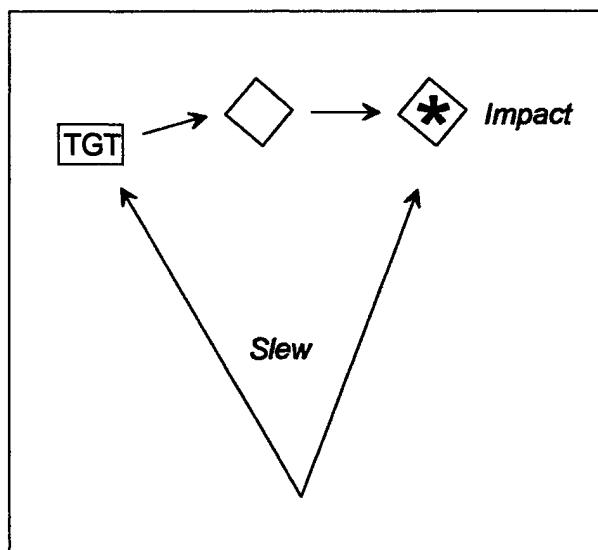
Indirect Fire Control

The FAC(A) must be able to control supporting arms such as artillery, naval surface fire support, and mortars when called upon. The pace of indirect fires is generally slow, and the F/A-18D has limited loiter time. The FAC(A) must therefore be expeditious in getting fires on target. In 1995, the Bats of VMFA(AW)-242 developed a method of controlling indirect fires rapidly using the advanced systems of the Hornet. It will be referred to as "The Bat Method" in this discussion. First, the FAC(A) must set up his system to control artillery (in this example). The FAC(A) WSO should have received the locations of the firing batteries when he checked in and stored them in open waypoints. Additionally, he should have done a radio check with the battery to ensure that he had good communications on the Artillery Air Spot or Conduct of Fire Nets. When the FAC(A) decides to use artillery, he should find out which battery will be shooting his mission. He should then make that battery location his A/A (air to air) waypoint so that it will show up on his HSI. This will give the crew spatial orientation on the moving map. The WSO should select steering to Mark 1 then designate the target to be struck by any means. The goal is to get the target under the diamond on the TFLIR display. This may require that the crew perform a "HUD assisted, FLIR designation." To do this, the FAC(A) pilot will take a lateral offset from the target the roll in and perform a HUD designation on the target. The WSO then refines the designation on the TFLIR. Once this is done the WSO should "drop" Mark 1 on the designation. He then dials in the course line so that the tail of the needle passes through the A/A waypoint. This line from the firing battery (the A/A waypoint) to the target (the designation) represents the gun target line (GTL). Referencing the HSI, the pilot sets up a parallel orbit along the left side of the GTL. This allows for the best TFLIR FOV. The diagram below shows the HSI and the FAC(A) orbit.



The crew is now ready to control the fire mission. When the WSO "dropped" Mark 1 on the designation it stored the grid to the target in the INS under the location of Mark 1 (the steer to waypoint). By going to the DATA page, the WSO can retrieve the grid to the target. After verifying the grid on a 1 : 50,000 chart, the WSO then sends a standard "adjust fire, grid" fire mission to the firing battery. The mission should be "at my command" for method of fire and control. This will allow the WSO to ensure that the aircraft is on the outbound leg toward the target when the rounds are fired. On the outbound leg the WSO must keep the target centered under the TFLIR diamond. If the target has drifted considerably, the WSO may need to slew the TFLIR back on target and perform an "UPDT-DSG-ACPT." This will re-orient the INS to the original position of the target when the designation was first performed, thus canceling the drift. When the first adjusting round is fired and impacts the earth, the WSO then slews the diamond from the target to the burst on the TFLIR display. He then selects "UPDT-DSG" on the HSI. At the top of the display he records the "drift" calculated by the INS (030 / .3 for example). He then selects "REJ" to cancel the bogus update. What the WSO has just done is trick the INS into believing that he was going to update the system on the location of the impact. Since the INS disagrees by the exact amount the WSO slewed the diamond from the target to the impact, the recorded drift (030 / .3) equals the bearing and distance from the target to the impact of the adjusting round in degrees true and tenths of nautical miles. In other words, it is the exact correction to get the next round on target. The WSO converts the data into the standard units and passes the correction to the firing battery: "Direction 035 degrees magnetic, drop 550." The WSO added the magnetic variation (5 degrees for demonstration) to the true bearing to get 035. There are about 183 meters per tenth of a nautical mile. This equates to about 550 meters for .3 nautical miles ($183 \times 3 = 549$). The next round should be within the effective radius of a 155-millimeter round, so the WSO may choose to "fire for effect" after this first adjustment. The Bats found that this was the case barring any inaccuracies on the part of the firing battery. With practice, the crew can get effect on target in less than five minutes from target identification. F/A-18D FAC(A) crews must maintain proficiency at the standard successive bracket method of adjusting fires so as not to become "system cripples." For standard adjustment procedures, the crew should still set up the same orbit and the HSI reference symbology. This will allow for simple corrections using the gun to target line (GTL) for reference. The checklist below can be used for the Bat Method:

1. Select steering to Mark 1.
2. Designate target by any method.
3. Center diamond on target with the TFLIR.
4. Drop Mark 1 on the designation / retrieve grid.
5. Send fire mission to the firing unit.
6. Select "UPDT-DSG-ACPT" (if needed).
7. Observe impact on TFLIR display (WSO may need to select wide FOV).
8. Slew diamond to the impact on TFLIR.
9. Select "UPDT-DSG" & record data.
10. Select "REJ" to cancel bogus update.
11. Convert data to degrees magnetic and meters.
12. Pass correction to the firing unit.

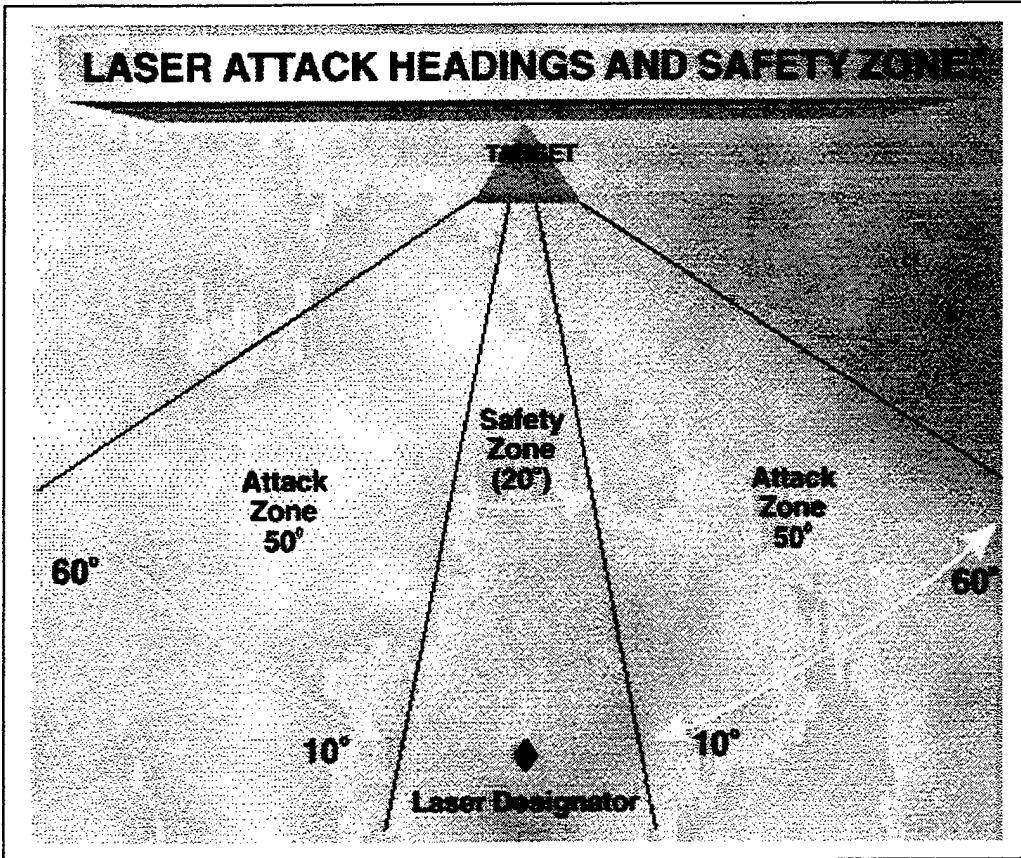


Laser Operations

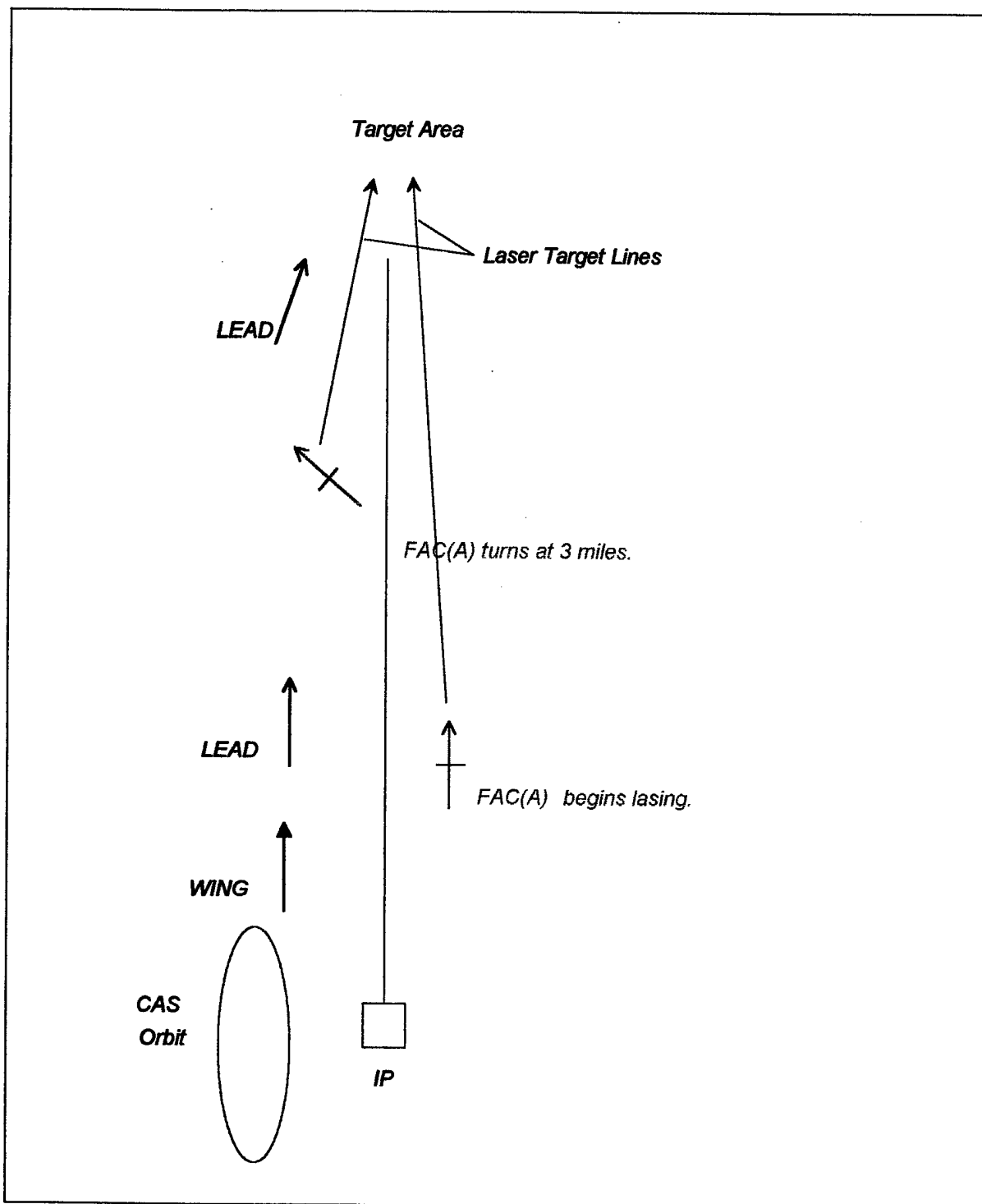
The F/A-18D FAC(A) must be prepared to employ the Laser Target Designator / Ranger (LTD/R) of the TFLIR to mark targets for attack. The LTD/R can be used to mark targets for aircraft equipped with laser spot trackers, or to provide laser terminal guidance for laser guided weapons. The use of laser marks is particularly effective at night. In fact, ground forward air controllers with ANGLICO in Desert Storm used lasers to control nearly all night CAS missions. At night, it is virtually impossible to determine whether a CAS aircraft is oriented on the proper target as he rolls in for the attack. During the day, we teach our FACs, to visually acquire each striker as he rolls in to determine that his flight path is lined up on the proper target before he is cleared to drop his ordnance. Neither a ground or airborne FACs can adequately accomplish this at night. By using a laser mark a target, and with well planned geometry for the attack, the FAC can be assured that the striker's bombs will hit the right place. If the striker reports that he has the "spot" there is little doubt that he can have effect on target. Marks such as WP and illumination rounds may provide good marks at night, but they can "wash out" night vision goggle over a wide area. Additionally, on a battlefield cluttered with burning vehicles, oil fires and the like, it may be impossible to distinguish a target mark from a burning tank. Combat conditions in the Gulf War proved that laser marks were the preferred method for night control of CAS.

The F/A-18D is not the ideal platform to laze for an external laser receiver because the Hornet moves across the battlefield at 400 to 500 knots which results in a constantly moving laser to target line. This can be difficult since the Hornet cannot maintain a static laser "basket" for the external receiver to "fly into." The best laser platform for control of precision CAS strikes is the Cobra. The NTS has a powerful laser designator which is tied to outstanding optics. From a stable hover, the Cobra can maintain a steady laser to target line which offers a much better chance of providing a reliable target mark. Unlike man portable laser designators which have limited battery life and are not quickly repositioned, the Cobra can maneuver quickly around the battlefield to seek the best location to laze from and control the mission. When possible, the Hornet FAC(A) would be smart to coordinate with the NTS Cobra for laser terminal guidance. When the Hornet FAC(A) must act as the laser platform, two simple methods of control can be used to maximize the use of the LTD/R. The first method is used when the target is either large in size or relatively easy to locate. The second method is used when the target is small or difficult to discriminate.

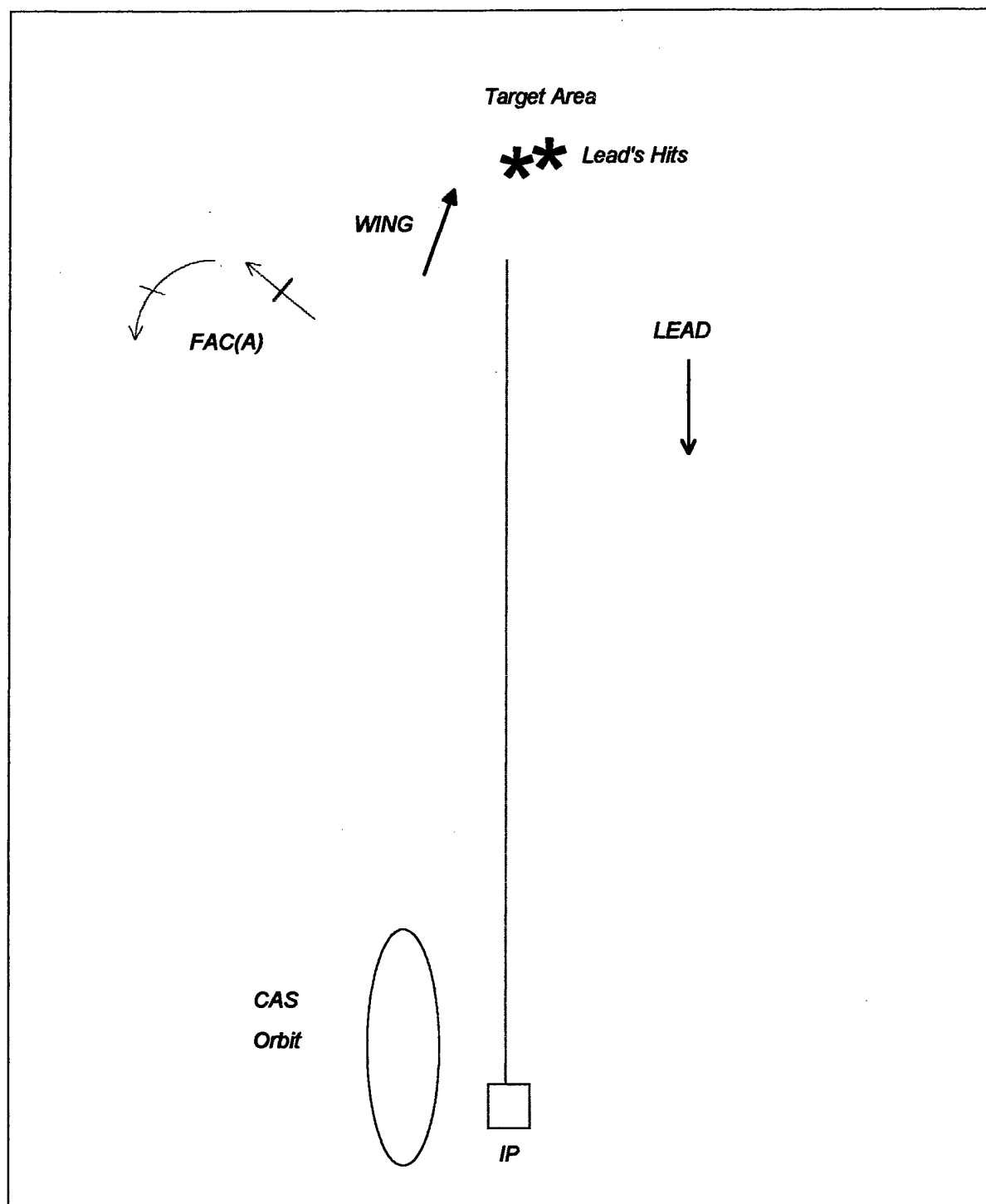
In the first method the Hornet FAC(A) locates and designates the target on the TFLIR. If he determines that the target is large or easy to locate, he may choose to leave the target area to join up with the CAS aircraft at the IP and guide them into the target. The diagram on page 156 shows how the FAC(A) loosely joins up with the strikers at the IP. Ideally, the FAC(A) would place the strikers on the left side of the IP to target line, while he positions himself stepped up in altitude on the right side of the lead aircraft. This will ensure the best TFLIR field of view looking left to right under the aircraft. No TOT should be necessary and the FAC(A) may command the strikers to "push" as soon as he has positioned the Hornet for the attack run. As the FAC(A) turns back inbound toward the target, the WSO must reacquire the target on the TFLIR. The crew must be set up for manual lazing. When the CAS lead calls for "laser on," the FAC(A) begins lazing the target. As the crew approaches around three miles, the FAC(A) should take a cut to the left so as not to fly directly over the target and keep the laser "basket" oriented toward the lead striker. As soon as the lead calls "Spot" then "Terminate," the FAC(A) ceases lazing and positions himself to best observe the strike. If the geometry works out perfectly then the FAC(A) should find himself behind the lead, looking through him toward the target area. After observing the impacts, the wingman is simply given a correction from lead's hits. The FAC(A) does not attempt to use the laser to mark for the wingman.



The diagram above shows the laser basket that the FAC(A) must attempt to get the strikers into to receive the laser spot. The 20 degree safety zone is designed to protect a ground or helicopter based laser designator. The CAS aircraft must maneuver into one of the two 50 degree attack zones. That FAC(A) must be conscious of this geometry at all times when involved in laser operations. The safety zone does not apply to the FAC(A) since there is little risk of fratricide to the fixed wing FAC(A), as long as he is properly positioned. The FAC(A) can be at risk from laser guided ordnance if he is positioned in such a way that the LTD/R is perceived as the target by the weapon. Lock on before launch is preferred for weapons like Hellfire and Laser Maverick.

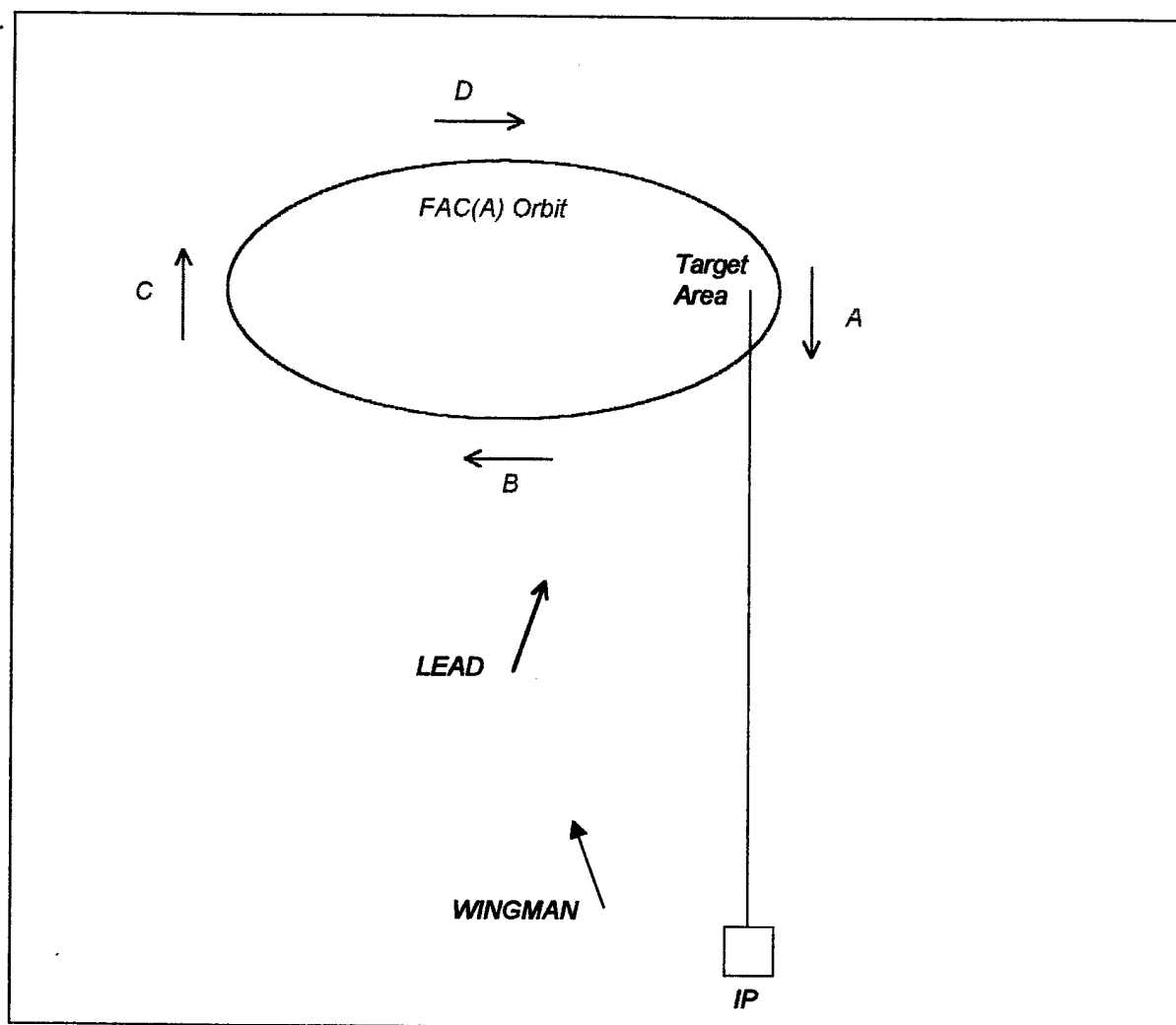


The diagram shows how the FAC(A) maneuvers to keep the basket properly oriented by executing the left turn toward and above the lead striker.



The FAC(A) controls the wingman by giving a correction from the lead fighter's hits. By taking the offset back at three miles, the FAC(A) allowed the wingman to close the distance and pass behind him to be controlled for his strike.

The second method of using the laser for terminal control is ideal for the night environment when the threat level is low and the targets are small or difficult to discriminate. The FAC(A) establishes an orbit above the target area in a right hand pattern as in the diagram below. The right hand pattern provides the best FLIR field of view. At night, the effectiveness of man pads is significantly reduced. Any optical or infrared guided forward area weapon will have limited ability to engage the FAC(A) in the overhead pattern. In the absence of radar guided systems, the FAC(A) should be able to execute this tactic. The orbit is flown at 15,000 feet AGL or higher if the scenario permits. The FAC(A) should use a standard 9Line brief to control the attack. The strikers should ingress below the FAC(A) orbit for altitude deconfliction during the attack. The FAC(A) begins lazering when the striker calls "laser on." The FAC(A) pilot must position the aircraft such that the laser basket is in the proper place. Ideally, the FAC(A) will laze from points A or B. Points C and D will not offer the best basket, but the strikers can potentially pick up the "spot" with the FAC(A) at any point in the orbit since much of the laser energy will be reflected directly upward toward the strikers as they roll in. The wingman can be adjusted from the lead's hits as was the case in the first method. The orbit is offset in the direction of the CAS ingress offset given in LINE TWO of the 9 Line brief.



The techniques, tactics, and procedures discussed in this appendix are not meant to indicate the only way that the F/A-18D FAC(A) can perform the myriad of supporting arms coordination tasks. FAC(A) crews should consider this as a point to start from when learning how to employ the Hornet in this mission area. As crews gain experience, they will undoubtedly come up with new and innovative ways to maximize the Hornet in the FAC(A) role. Newer technologies will offer many improvements in F/A-18D employment. GPS equipped aircraft, for example will be able to modify the Bat Method of indirect fire control by simply dropping a mark on the impact of the first adjusting round and sending the firing unit a ten digit grid. The MAWTS FAC(A) handbook as well as the MAWTS academic support packages offer additional information to educate FAC(A) crews. The intent of this document is augment the MAWTS products by offering more hands on, cockpit oriented recommendations for conducting the FAC(A) mission.

SAC(A) Checklist

INFORMATION

- ☐ Mission
 - ◆ Alternate(s)
- ☐ Mission #
- ☐ Callsign(s)
- ☐ TOS
- ☐ Ordnance Required
 - ◆ Codes
- ☐ Operating area
 - ◆ Times
 - ◆ Altitudes
- ☐ Weather
 - ◆ Local
 - ◆ Enroute
 - ◆ Working Area
 - ◆ Diverts
 - ◆ Moon/Sun data
 - ◆ EOTDA data
- ☐ Fuel
 - ◆ Joker/Bingo
 - ◆ Tanker Plan
- ☐ Communications
 - ◆ Comm 1/2 Plan
 - ◆ Escort Common
 - ◆ Coordination Frequency
 - ◆ ACEOI day
 - ◆ Data Link Plan
 - ◆ KY-58
- ☐ INS
 - ◆ Waypoints Required
 - ◆ Sequences
 - ◆ Speriod in use
 - ◆ Datum in use
- ☐ Rendezvous
 - ◆ Point
 - ◆ Altitude
 - ◆ Procedure
- ☐ RTF Profile
- ☐ Recovery

SOURCES

- (ATO)
- (ATO)
- (ATO)
- (ATO/ACEOI)
- (ATO)
- (ATO/ANNEX M)
- (ATO/ANNEX M-6)
- (ATO)
- (ATO)
- (ATO)
- (MWSS)
- (MWSS)
- (MWSS)
- (MWSS)
- (MWSS)
- (MWSS/MOON/TAMPS)
- (MWSS)
- (UNIT SOP)
- (ATO)
- (SOP)
- (ATO/ACEOI/SOP)
- (ATO/ANNEX-K/ACEOI)
- (ATO/ANNEX K)
- (ATO/ANNEX K)
- (ATO/ANNEX K)
- (ATO/ANNEX M-4)
- (SOP)
- (ATO/ANNEX B)
- (ATO/ANNEX B)
- (ATO/ANNEX M-4)
- (ATO/ANNEX M-4)
- (SOP)
- (ATO/ANNEX M-4)
- (SOP/ANNEX M-14)

Enclosure (1)

ENEMY SITUATION

☐ Ground Order of Battle (ANNEX B/INTELL)

◆ Locations

"

◆ Infantry

"

◆ Artillery

"

◆ Armor

"

◆ Possible Objectives

"

☐ Air Order of Battle

"

◆ Surface to Air

(ANNEX B/INTELL/TAMPS)

◆ Air to Air

(ANNEX B/INTELL)

☐ Electronic Order of Battle

(ANNEX B/INTELL/TERPES)

☐ Threat Assessment

"

◆ Counters

"

FRIENDLY SITUATION

☐ General Overview (ANNEX C/OPS O)

☐ Ground scheme of maneuver

(ANNEX C-12/OPS O)

◆ Locations

"

◆ Units

"

◆ FLOT/FEBA

"

◆ Objectives

"

◆ Maneuver Control Measures

(ANNEX C/OPS O)

◆ Boundaries

"

◆ TAORS

"

◆ Phase Lines

"

◆ Fire Support

(ANNEX C-12/FSC/ALO/AO)

◆ Type

"

◆ Location

"

◆ Callsign

"

◆ GTL's

"

◆ Fire Fan

"

◆ FSC Measures

(ANNEX C-12/FSC)

◆ CFL(s)

"

◆ FSCL(s)

"

◆ RFA(s)

"

◆ NFA(s)

"

◆ RFL(s)

"

◆ FFA(s)

"

◆ ACA(s)

"

◆ Fire Plan

ANNEX C-12/FSC)

◆ Target List

"

◆ Precedence

"

◆ Preplanned Fires/JTARS

"

Enclosure (1)

INFORMATION

☐C³

- ◆Airspace
 - ◆MRR's
 - ◆Control Points
 - ◆ACA's
- ◆Communications
 - ◆Agencies
 - ◆Callsigns
 - ◆Nets
 - ◆Frequencies
 - ◆RIO Procedures
 - ◆Code/Pro Words
 - ◆Chattermark Plan
 - ◆BDA Flow
 - ◆Authentication Procedures
- ◆Visual Signals
 - ◆Pyro/illum
 - ◆Panels

SOURCES

(ANNEX M-4/ATO)
(ANNEX M-4/ATO)
(ANNEX C-12/ATO)

(ANNEX K/ATO/ACEOI)
"
"
"
(ANNEX M-12/ATO)
(ATO/ACEOI)
(ANNEX K/ATO)
(ANNEX M-2,8/ATO)
(ANNEX K/ATO/ACEOI)
(ANNEX K)
"
"

TERMINAL CONTROL PROCEDURES

☐FAC(A) Stationing

- ◆Position
- ◆Altitude
- ◆Formation

☐Attack Profiles

- ◆Low threat
- ◆Medium threat
- ◆High threat

☐CAS Asset Stationing

- ◆CP's/HA's
- ◆IP's
- ◆Expected tactics

☐Fire Support Coordination Plan

- ◆Agencies/Callsigns/Nets
- ◆Combined/Sequential ops

☐SEAD Plan

- ◆On Call OAAW plan

☐LGW Considerations

- ◆Laser Code
- ◆Comm
- ◆Restrictions

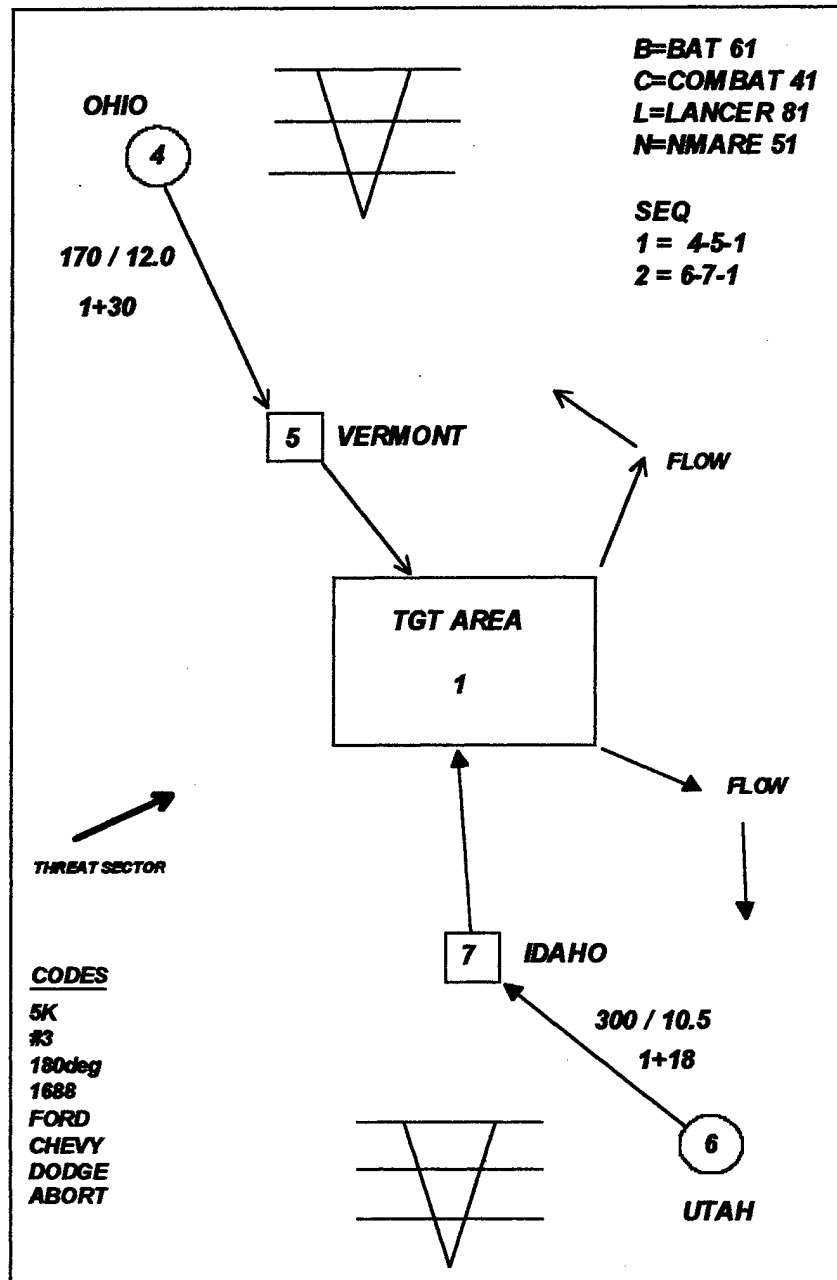
☐Reasonable Assurance

(ANNEX M-2/AO)
"
"
(UNIT UNIT SOP)
(UNIT UNIT SOP)
"
"

(ANNEX M-4/AO)
(ANNEX M-4/AO)
(ACE)
(ANNEX C-12/FSC/AO)
(ANNEX C-12/ACEOI/FSC/AO)
(ANNEX C-12/FSC/AO)
(ANNEX C-12/FSC/AO)
(ANNEX C-12/FSC/ATO)
(ANNEX C-12/FSC/AO)
"
"
"
(FSC/AO/ATO)

Enclosure (1)

SA CARD



Enclosure (2)

FAC(A) Admin Card

CALLSIGN	MISSION #	WALK	START	CHECK	TAXI	ITO	RTB
AIRSPACE				FM	TO	J	B
TANKER	TRACK	ALT	FREQ	TCN	GIVE	J	B
CALLSIGN	CREW			A/C	TCN	RDR	IFF
MISSION #	CALL SIGN # / TYPE	TOS	ORD	CP / ALT	TIME IN / OUT	TGT	
CH	FREQ	COLOR	AGENCY	CALLSIGN	CODEWORDS		
					CONTINUE		
					CHANGE		
					CANCEL		
					ABORT		
					BASE ALT		
					BASE #		
					BASE HDG		
					LASER		

Enclosure (3)

Joint Tactical Airstrike Request

FAC(A) JTAR		Date: _____	
1. Unit called _____	This Is _____	Request # _____	
			Sent _____
2. Preplanned: A Precedence B Priority			Time By _____
Immediate C Priority			Rec'd _____
3. Target is number of: _____			Time By _____
A Pers In Open _____ B Pers Dug In _____ C Wpns/MG/RR/AT _____ D Mortars/Arty _____ E AAA/ADA _____ F Rockets/Missiles G Armor _____ H Vehicles _____ I Bldgs _____ J Bridges _____ K Pillbox, Bunkers _____ L Supplies, Equip _____ M Center (op,com) N Area _____ O Route _____ P Moving N,S,E,W _____ Q Remarks _____			
4. Target location is: _____			Checked By _____
A _____ B _____ C _____ D _____ E Tgt Elev _____ F Sheet # _____ G Series _____ H Chart # _____			
5. Target time/date _____			
A ASAP _____ B NLT _____ C At _____ D To _____			
6. Desired Ord/Results: A Ordnance _____			
B Destroy _____ C Neutralize _____ D Harass/Interdict _____			
7. Final Control: _____			
A FAC _____ B Callsign _____ C Freq _____ D ASRT _____ E Freq _____ F Fix/Cont _____			
8. Remarks: _____			
1)JP/AP _____		9)Egress _____	
2)Hdg _____ Mag Offset: L/R _____		Beacon _____	
3)Dist _____		Bearing/Dist _____ Grid Method _____	
4)Tgt Elev _____ Ft. MSL _____		10)Bcn-Tgt _____ Mag Bcn _____ / _____	
5)Desc _____		11) Bcn-Tgt _____ Mtrs Tgt _____ / _____	
6)Tgt Loc _____		12)Bcn Elev _____ Ft MSL _____	
7)Mark Type _____ Code _____		Acknowledged _____	
8)Friendlies _____		BDE/Regt _____	
		Division _____	
		Other _____	
SECTION III - Mission Data			
20. Msn # _____	21. Callsign _____	22. #/Type A/C _____	23. Ordnance _____
24. Est/Act Takeoff _____	25. Est TOT _____	26. Cont Pt _____	27. Initial Contact _____
28. FAC/Callsign/Freq _____	29. Rest Fire/Air Plan _____	30. Tgt Desc _____	31. Tgt Coord / Elev _____
32. BDA _____			

Enclosure (4)

FAC(A) Communications Cards

COMM 1				
	AGENCY	FREQUENCY	CALLSIGN	COLOR
C				
M				
1	ATIS			
2	CLEARANCE			
3	GROUND			
4	TOWER			
5	TATC 1			
6	TATC 2			
7	TATC 3			
8	TATC 4			
9	SPARE			
10	SPARE			
11	TAD 1			
12	TAD 2			
13	TAD 3			
14	TAD 4			
15	ADA			
16	TANKER (P)			
17	TANKER (S)			
18	SPARE			
19	SPARE			
20	BASE			

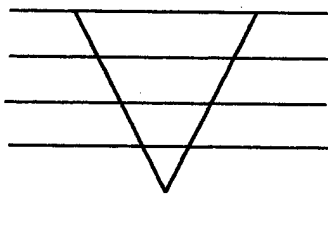
Enclosure (5)

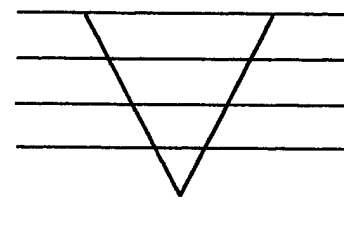
COMM 2				
	AGENCY	FREQUENCY	CALLSIGN	COLOR
C				
M				
1	TAR/HR 2/3			
2	TACP(L) / REGT SAC(A) (proposed)			
3	ARTY (AIR SPOT)			
4	ARTY COF			
5	MORTAR COF			
6	NGF (AIR SPOT)			
7	BN TAC			
8	REGT TAC			
9	SPARE			
10	SPARE			
11	REGT FSOC			
12	AIR OBS NET			
13	INTELL NET			
14	SPARE			
15	TAC			
16	TAC			
17	TAC			
18	TAC			
19	ATIS			
20	BASE			

Enclosure (5)

FAC(A) 9LINE CARD

JTAR #				NM	480	540
CP				4	30	27
1. IP				5	38	33
2. HDG O/S	L/R	L/R	L/R	6	45	40
3. DIST				7	53	47
4. ELV				8	60	53
5. DESC				9	1+08	1+00
6. COORD				10	1+15	1+07
				11	1+22	1+13
7. MARK				12	1+30	1+20
8. FRNDL				13	1+38	1+27
9. EGGR				14	1+45	1+33
REMARKS				15	1+53	1+40
				16	2+00	1+47
				17	2+08	1+53
				18	2+15	2+00
TOT				MAG VAR		
BDA						





Enclosure (6)

FAC(A) Call For Fire Card

1.	THIS IS BAT _____,	<u>MAX ORD</u>
2.	<input type="checkbox"/> ADJUST FIRE <input type="checkbox"/> FIRE FOR EFFECT <input type="checkbox"/> SUPPRESS <input type="checkbox"/> IMMEDIATE SUPPRESSION SHIFT _____ (TARGET #), OVER. <u>GUN TGT LINE</u> <BREAK>	
3.	GRID _____ (OR) (SHIFT) DIRECTION _____ deg. mag. (SHIFT) DISTANCE _____ meters, OVER. <BREAK>	
4.	TGT DESCRIPTION: _____.	
5.	METHOD OF ENGAGEMENT: <input type="checkbox"/> DANGER CLOSE <input type="checkbox"/> PROJECTILE (omit if HE) <input type="checkbox"/> FUZE (omit if quick) <input type="checkbox"/> RNG. / LAT. SPREAD	
6.	METHOD OF FIRE & CONTROL: <input type="checkbox"/> REQUEST SPLASH <input type="checkbox"/> AMC <input type="checkbox"/> TOT _____, OVER... <BREAK>	
<u>MESSAGE TO OBSERVER:</u>		
UNIT TO FIRE _____		CHANGES _____
NO. OF ROUNDS _____	TGT # _____	TOF _____
<u>ADJUST FIRE-GRID</u> -B2F, <de> Bat 61, adjust fire, over -Grid PG 123456, over -4 APCs, ICM in effect, AMC, over... (MTO copy & read back)		<u>SEAD</u> -B2F <de> Bat 61, SEAD, over -Suppression grid PG123456, Mark grid PG654321 -WP, TOT 1543, over... (if mark only, omit 'Suppression...')
<u>IMMEDIATE SUPPRESSION</u> -B2F <de> Bat 61, Immediate Suppression Grid PG123456, over...		
Refinement _____ / _____, Record as target Y / N , End of mission,		
Surveillance _____.		


Enclosure (7)


FAC(A) Waypoint Card

#	WYPT	Lat / Long Grid E / N	Elv.	O/S Data
0		/		
1		/		
2		/		
3		/		
4		/		
5		/		
6		/		
7		/		
8		/		
9		/		
10		/		
11		/		
12		/		
13		/		
14		/		
15		/		
16		/		
17		/		
18		/		
19		/		
20		/		
21		/		
22		/		
23		/		
24		/		

Enclosure (8)


APPENDIX B






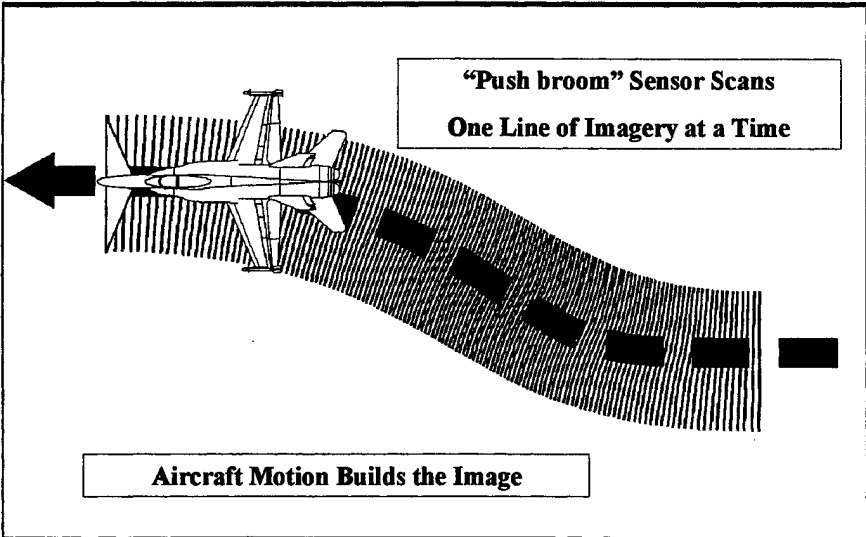
ATARS

Advanced Tactical Airborne
Reconnaissance Set





ATARS Sensors



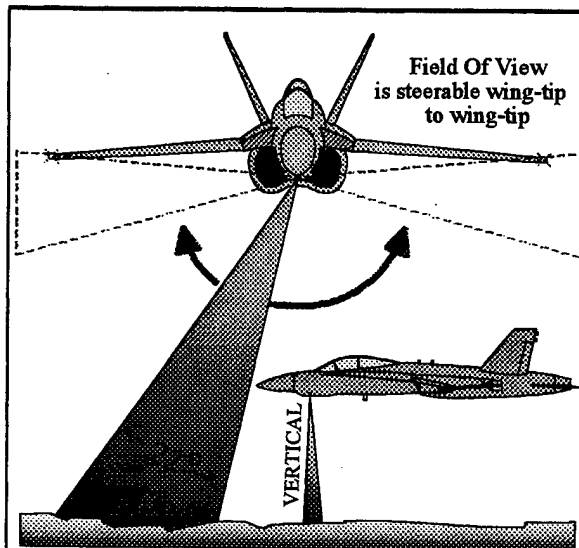
"Push broom" Sensor Scans
One Line of Imagery at a Time

Aircraft Motion Builds the Image

The diagram illustrates the "push broom" sensor scanning process. It shows a side profile of an aircraft moving from right to left, as indicated by a large black arrow. Behind the aircraft, a series of vertical lines represent the sensor's field of view. As the aircraft moves, these lines sweep across the ground, creating a continuous image. The text "Aircraft Motion Builds the Image" is placed at the bottom of the diagram. A separate text box above the aircraft states "Push broom" Sensor Scans One Line of Imagery at a Time.



Medium Altitude Electro-Optical



MAEO

FIELD OF VIEW
22°

ALT/SLANT RANGES
3,000 FT - 25,000 FT

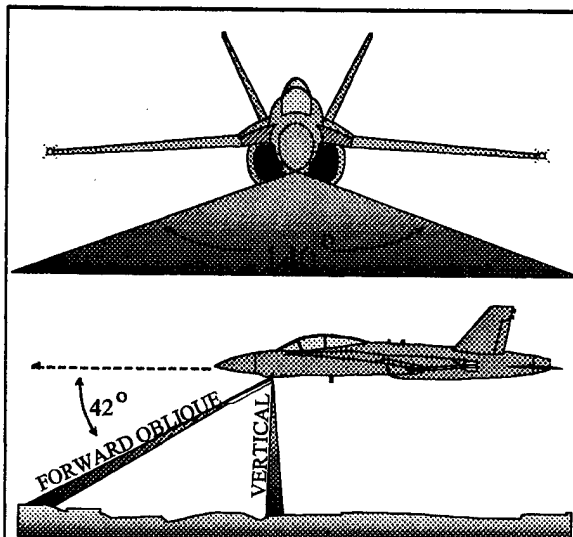
AIRSPEEDS
200 KGS - 600 KGS

STABILIZATION
NORMAL
(Stabilized to ground))

OVERRIDE
(Caged to aircraft)



Low Altitude Electro-Optical



LAEO

FIELD OF VIEW
140°

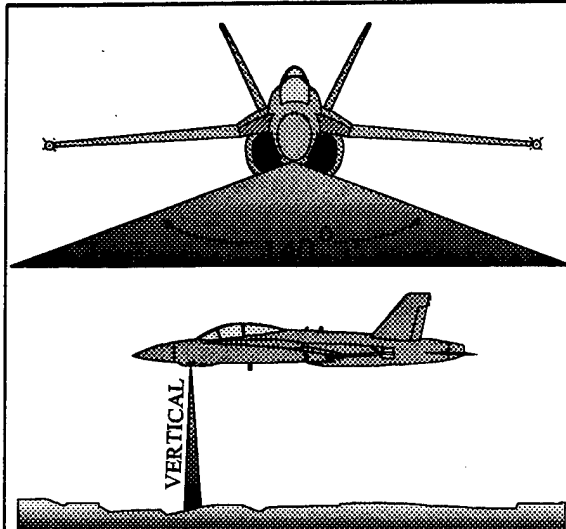
ALTITUDES
200 FT - 3,000 FT AGL

AIRSPEEDS
200 KGS - 600 KGS

MODES
VERTICAL
(Straight down)
FORWARD OBLIQUE
(42 degrees depression)



Infrared Line Scanner (Wide)



IRLS Wide

FIELD OF VIEW
140°

ALTITUDES
200 FT - 3,000 FT AGL

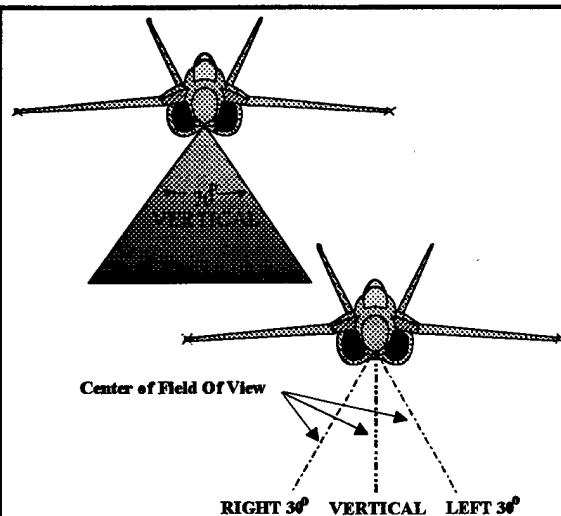
AIRSPEEDS
200 KGS - 600 KGS

STABILIZATION
NORMAL
(Stabilized to ground))

OVERRIDE
(Caged to aircraft)



Infrared Line Scanner (Narrow)



IRLS Narrow

FIELD OF VIEW
70°

ALTITUDES
3,000 FT - 25,000 FT AGL

AIRSPEEDS
200 KGS - 600 KGS

MODES
LEFT (30°)
RIGHT (30°)
VERTICAL (Down)



Radar



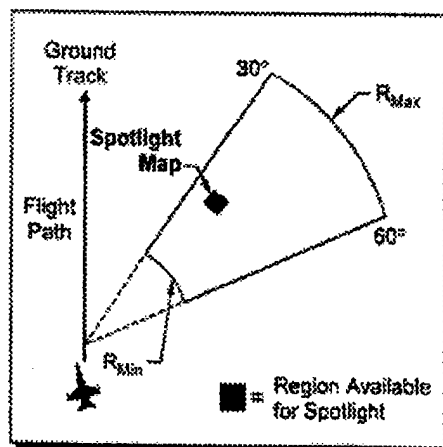
- APG-73 must be upgraded to RUG II for Recce SAR capability
- 3 new radar components fit into existing radar racks (including a strap down INS)
- Aircraft envelope for SAR imagery:
 - 2,000 to 40,000 ft Above Ground Level
 - 240 to 590 Knots Ground Speed
- All-weather sensor
- SAR imagery not displayed in the cockpit
 - Requires post mission processing at ground station



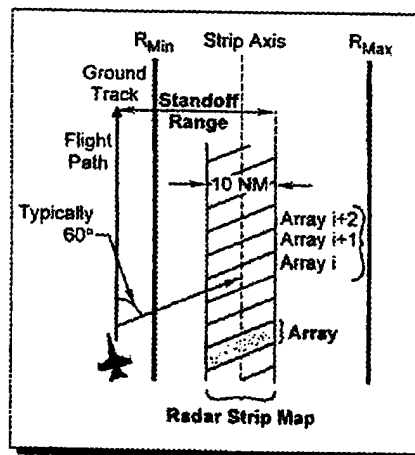
Radar Recce Modes



Spotlight Map



Strip Map





ATARS Data Link Pod



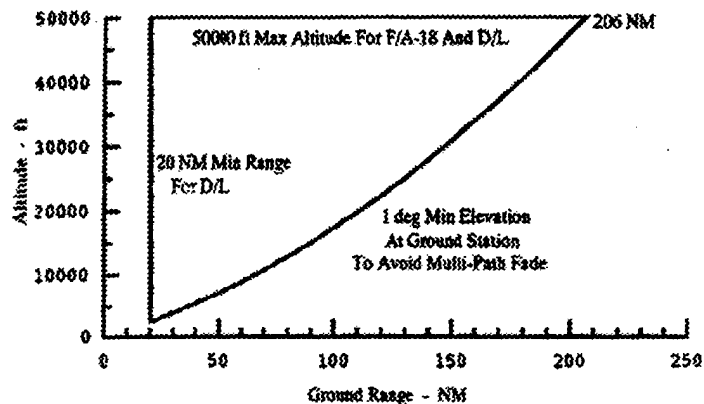
- Carried on the aircraft's centerline station.
- 560 lbs., 9 feet long, 25 inch diameter pod.
- Can jettison the pod in an emergency.
- Near real time data link.
- 9 inch antenna with pointing coverage of:
 - $\pm 135^\circ$ azimuth
 - $+35^\circ$ to -85° elevation



Data Link Operating Envelope



CURVED EARTH GEOMETRY WITH REFRACTION



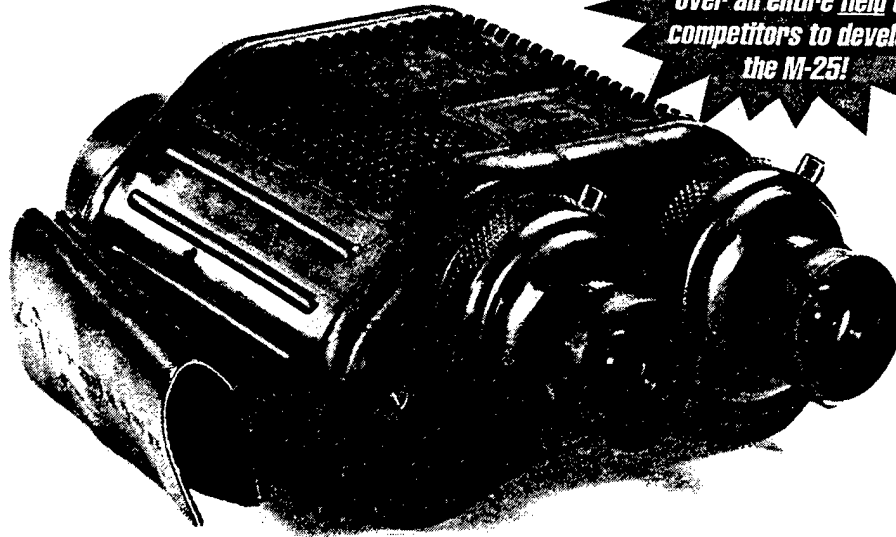
Fraser-Volpe Corporation



STEDI-EYE[®] M-25
Stabilized 14X Binoculars

NSN 1240-01-410-7418

***Fraser-Volpe...**
Chosen by the US Army
over an entire field of
competitors to develop
the M-25!*



**The most sophisticated hand-held
binoculars ever engineered.**
With Night Vision Capability!



Fraser-Volpe Corporation

Corporate Headquarters: 1025 Thomas Drive, Warminster Industrial Park, Warminster, PA 18974, U.S.A.
Telephone: 215-443-5240 FAX: 215-443-0966 e-mail: FraserVolp@aol.com

The M-25 offers world-class performance for surveillance and investigation!

Own the most sophisticated hand-held binoculars ever engineered.

The Stedi-Eye M-25 removes up to 98% of image motion due to platform vibration.

The STEDI-EYE M-25 is a stabilized hand-held binocular that virtually eliminates image motion due to hand tremor and platform vibration—a common problem associated with conventional binoculars and telescopes. The M-25 allows objects to be seen 14 times closer than with the naked eye, while allowing a greater field of view, for accurate identification of people and objects.

Engineered to perform under the most demanding military field conditions.

Fraser-Volpe Corporation developed the M-25 under contract with the U.S. Army, but markets the device commercially without the classified laser filters. Though

Exclusive touch-sensitive cage/uncage feature automatically secures the gimbal when not in use.

One of the most unique features of the M-25 is its automatic touchpad cage/uncage capability. The mere act of picking up and holding the M-25 automatically activates the stabilization mode. Likewise, simply lying down the unit locks the gimbal to prevent potential damage. This feature gives the M-25 an essential advantage over other image-stabilization binoculars, which have been known to suffer damage after only a few days in the field.

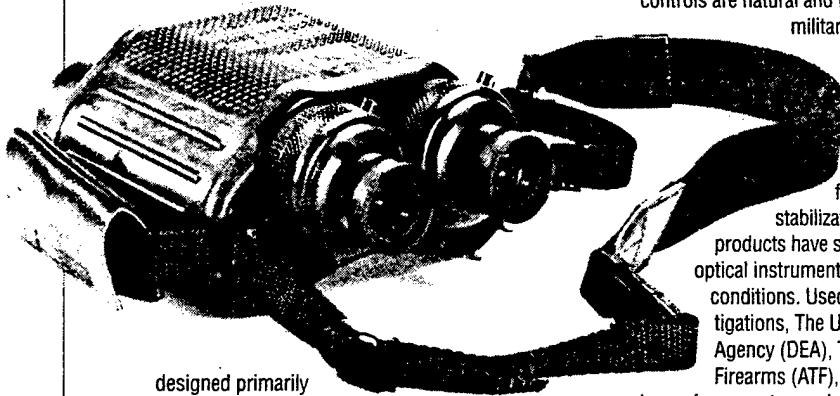
A rubberized boot gives the M-25 a rugged exterior finish while maintaining extraordinary responsiveness from the touch-sensitive control pad located at the top of the unit. Balance is excellent: focus and interpupillary controls are natural and intuitive. The M-25 is fully militarized, waterproof and floatable

The Stedi-Eye M-25 reflects Fraser-Volpe's 23 years of leadership in stabilized optical systems.

Fraser-Volpe pioneered the first generation of active image stabilization binoculars. Since 1972, our products have set the standard for high-quality optical instruments for use under demanding field conditions. Used by the Federal Bureau of Investigations, The United States Drug Enforcement Agency (DEA), The Agency of Tobacco and Firearms (ATF), The US Coast Guard and other law enforcement organizations, Fraser-Volpe optical systems are considered mission-critical tools for investigation and surveillance in a wide range of non-military applications.

Easily interfaces with any standard SLR camera to permit photo-documentation!

The M-25 features a universal camera adapter that allows users to perform photo-reconnaissance while continuing to scan the scene through the camera lens. This enables field personnel to document objects and events photographically. Users have reported amazing results from the field, such as clearly legible photographs of license plate numbers on vehicles more than 300 yards away.

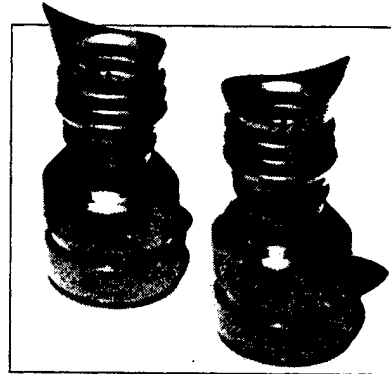


designed primarily for military applications, the M-25 provides a compact, low-cost solution for use in a wide range of applications and from moving vehicles of all types, including aircraft, boats, automobiles and other vehicles. Using the M-25, field agents can easily view (and photograph) people and events from a moving boat and produce clear, steady images with remarkable detail. It's the finest set of binoculars you can own.

Due to its unequalled performance, The Stedi-Eye M-25 represents the ultimate weapon for law enforcement agencies to support surveillance and investigative units in the field, with up to 98% of all input motions being removed from the image being viewed.

***With Fraser-Volpe's Stedi-Eye M-25,
you can switch to NIGHT VISION
by simply changing eyepieces!***

The Stedi-Eye M-25 is configured to accept special eyepieces which allow the unit to be used in near-total darkness. These night vision adapters employ the same image intensification technology used by the U.S. military to deliver exceptional image clarity under extreme low-light conditions. Fraser-Volpe's Stedi-Eye M-25 enables agents and other personnel to safely gather detailed, documentable evidence and information from the field, maximizing the effectiveness of any investigative effort. Utilizes Gen II or Gen III image intensifier tubes.

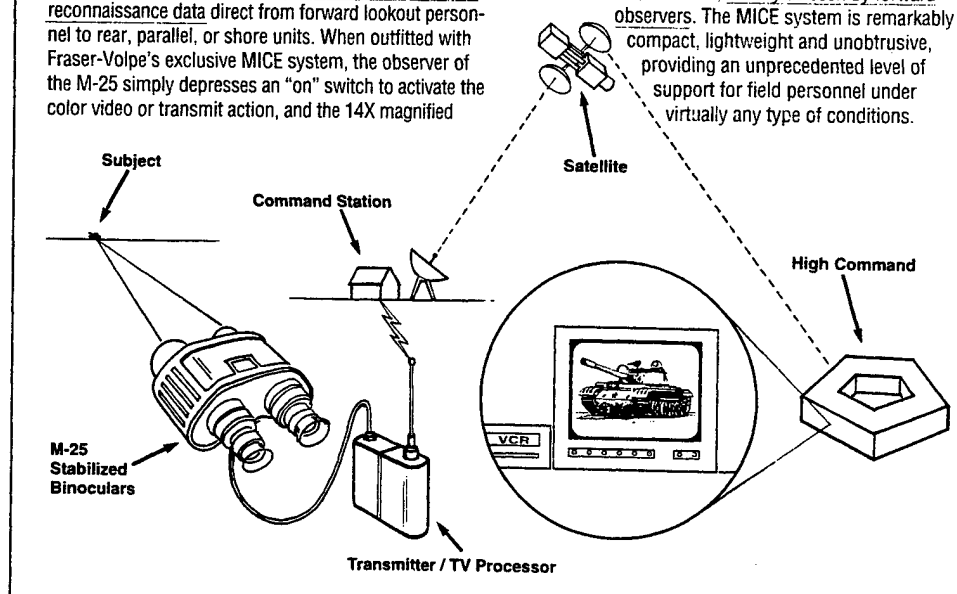


***The M-25 is fully compatible with Fraser-Volpe's exclusive
Miniature Integrated Camera Eye (MICE)[®] system.****

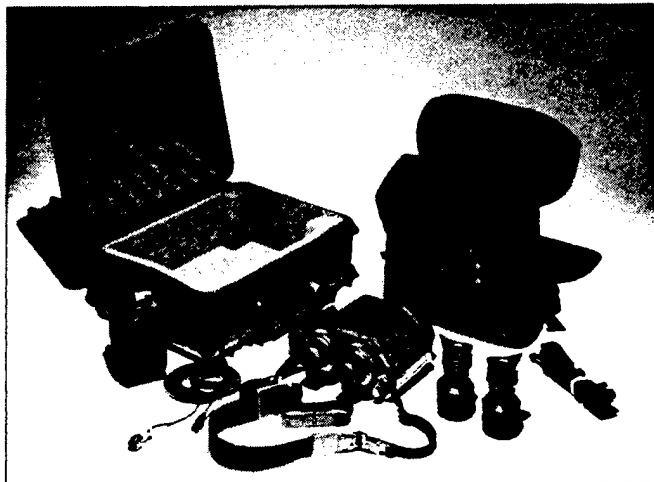
Transmit real-time video images to a control center located miles away!

Imagine your support team sharing real-time video surveillance with an operator located miles away! With the recent development of improved micro-cameras it is now possible to permanently record or transmit on-the-spot reconnaissance data direct from forward lookout personnel to rear, parallel, or shore units. When outfitted with Fraser-Volpe's exclusive MICE system, the observer of the M-25 simply depresses an "on" switch to activate the color video or transmit action, and the 14X magnified

image can then be transmitted by wireless link to a command station located up to 20 miles away (line of sight). This gives remote stations the ability to monitor surveillance data, real-time, exactly as seen by forward observers. The MICE system is remarkably compact, lightweight and unobtrusive, providing an unprecedented level of support for field personnel under virtually any type of conditions.



* Patent pending

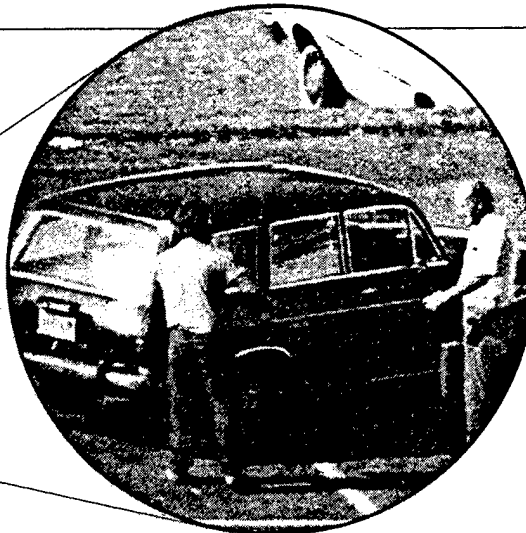
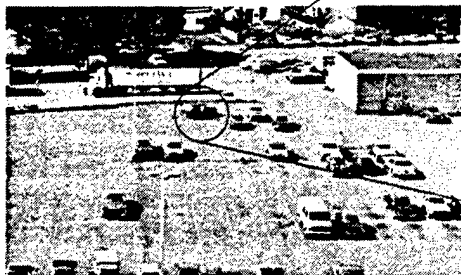


The Stedi-Eye M-25 comes with a durable carrying case and a complete range of available accessories.

- Molded, High-Impact, Foam-Lined Carrying Case
- Soft-Sided Field Carrying Case
- Special "Arctic Pack" battery case for optimum cold weather performance
- Neck Strap
- Available Night Vision Eyepieces
- Flexible Cord to Connect to Power Supply
- Cover to Protect Eyepieces
- Pouch for Extra Batteries
- Detailed Operator's manual

Profit from more than 23 years of continuous product enhancement.

Like all of Fraser-Volpe's products, the Stedi-Eye M-25 offers unequalled performance and uncompromising quality. There is absolutely no better value in the field of gyro-stabilized binoculars. Don't settle for less!



M-25 UNIT SPECIFICATIONS

Magnification	14X	Maximum Scan Rate* 5-10 Degree/Sec.	
Objective Diameter	41 MM	Interpupillary Adjustment .. 60-72 MM	
Exit Pupil	3 MM	Power (internal)	2 AA Cells
Field of View	4.3 Degrees	Power (external)	6-30 VDC
Resolution (Day)	4.3 Sec	Length (day)	8.25" (210 MM)
Resolution (Night) >35 Line Pairs/MM		Length (night)	9.0" (229 MM)
Stabilization Freedom	± 9 Degrees	Width	7.5" (190 MM)
Focus Adjustment	± 5 Diopters	Height	3.5" (89 MM)

* FACTORY ADJUSTABLE

For additional information about Stedi-Eye M-25 Binoculars, please contact:

Authorized Dealer



Fraser-Volpe Corporation 1025 Thomas Drive, Warminster, PA 18974 U.S.A. 215-443-5240 FAX: 215-443-0966
e-mail: FraserVolp@aol.com

APPENDIX D
FUEL CALCULATIONS
FOR STANDARD
FAC(A) AND TAC(A) CONFIGURATIONS

The fuel calculations on the next three pages are based on a 300 nautical mile round trip from take off at Marine Corps Air Station Miramar, San Diego, California to the R-2301W training area near Marine Corps Air Station Yuma, Arizona. The intent of these calculations is to show the computed endurance of the F/A-18D operating from a departure air base 150 nautical miles from the Forward Line of Troops (FLOT). The first calculation indicates the endurance of the F/A-18D carrying a standard FAC(A) load working at 15,000 feet mean sea level. This profile allowed the FAC(A) to delay forty-two minutes time on station (TOS). The second page shows the F/A-18D with a standard TAC(A) load with two external fuel tanks which allowed a one hour and twenty-nine minutes TOS at 28,000 feet mean sea level. The third page shows the same TAC(A) load but with three external fuel tanks which equates to one hour and fifty minutes TOS at 30,000 feet mean sea level.

These calculations are computed at 400 knots ground speed for all three profiles to simulate maximum endurance. In reality, the F/A-18D will only be able to achieve these endurance figures if the crew maintains a non-aggressive orbit near the FLOT for the entire mission at the aforementioned altitudes. For TAC(A) only missions, which are largely command and control in nature, the F/A-18D crew may come close to achieving the maximum TOS. For FAC(A) missions, however, the crew will have to maneuver the jet aggressively at times to locate and mark CAS targets, and control the strikers. The FAC(A) will not normally achieve the maximum TOS.

FPLAN version 9.3: FLIGHT PLAN and LOG route: YUMAFAC form: BRICK
 Ref: A1-F18AC-NFM-200 (400 Eng) Mil Thrust Climb, Standard Cruise

 FREQUENCIES

TP	ROUTE FIX	FREQ	LAT LON	EL FL	MH MC	DIST	CAS GS	ETE ETA	FUEL
	STTO KNKX	33	N 325211 W1170917	430 430				+00+00 00:00:00	1500 12600
	KIPL	106 115.9	N 324456 W1153031	-20 29000	080 080	83.3 83.3	315C 480G	+11+19 00:11:19	2016 10584
	KNYL	84	N 323849 W1143648	180 25000	083 083	45.6 129.0	315C 480G	+05+42 00:17:01	555 10028
	DELA NYL090030	84	N 323129 W1140217	180 15000	090 090	30.0 159.0	277C 400G	+45+50 01:02:51	5581 4448
	ktrm	109 116.2	N 333741 W1160937	-110 28000	288 288	125.6 284.5	320C 480G	+16+23 01:19:14	2070 2378
	KNKX	33	N 325211 W1170917	430 430	215 215	67.5 352.1	150C 151G	+08+26 01:27:40	306 2071

Starting Configuration:
 2 AIM-9 (SIDEWINDER) [WING TIP]
 4 WING PYLON
 2 VER [PYLON]
 1 CL PYLON
 2 330 GAL TANK [WING]
 4 LAU-10 D/A (5") FARING OFF [VER]
 1 TFLIR [FUSELAGE]
 1 LDT [FUSELAGE]
 1 MK-82 HD [PYLON]

FPLAN version 9.3: FLIGHT PLAN and LOG route: YUMATAC form: BRICK
 Ref: A1-F18AC-NFM-200 (400 Eng) Mil Thrust Climb, Standard Cruise

 FREQUENCIES

TP	ROUTE FIX	FREQ	LAT LON	EL FL	MH MC	DIST	CAS GS	ETE ETA	FUEL
	STTO KNXX	33	N 325211 W1170917	430 430				+00+00 00:00:00	1500 12600
	KIPL	106 115.9	N 324456 W1153031	-20 29000	080 080	83.3 83.3	315C 480G	+10+29 00:10:29	1506 11094
	KNYL	84	N 323849 W1143648	180 28000	083 083	45.6 129.0	315C 480G	+05+42 00:16:11	479 10615
	DELAY NYL090030	84	N 323129 W1140217	180 28000	090 090	30.0 159.0	263C 400G	1+33+30 01:49:41	6972 3643
	ktrm	109 116.2	N 333741 W1160937	-110 28000	288 288	125.6 284.5	320C 480G	+15+42 02:05:23	1307 2336
	KNXX	33	N 325211 W1170917	430 430	215 215	67.5 352.1	150C 151G	+08+26 02:13:49	306 2030

Starting Configuration:
 2 AIM-9 (SIDEWINDER) [WING TIP]
 4 WING PYLON
 1 CL PYLON
 2 330 GAL TANK [WING]
 1 TFLIR [FUSELAGE]
 1 LDT [FUSELAGE]

FPLAN version 9.3: FLIGHT PLAN and LOG route: YUMATAC2 form: BRICK
 Ref: A1-F18AC-NFM-200 (400 Eng) Mil Thrust Climb, Standard Cruise

 FREQUENCIES

TP	ROUTE FIX	FREQ	LAT LON	EL FL	MH MC	DIST	CAS GS	ETE ETA	FUEL
	STTO	33	N 325211	430				+00+00	1500
	KNKX		W1170917	430				00:00:00	14600
	KIPL	106 115.9	N 324456 W1153031	-20 29000	080 080	83.3 83.3	315C 480G	+10+32 00:10:32	1601 12999
	KNYL	84	N 323849 W1143648	180 30000	083 083	45.6 129.0	310C 480G	+05+42 00:16:14	523 12476
	DELAY NYL090030	84	N 323129 W1140217	180 30000	090 090	30.0 159.0	254C 400G	1+54+30 02:10:44	8921 3555
	ktrm	109 116.2	N 333741 W1160937	-110 28000	288 288	125.6 284.5	310C 480G	+15+42 02:26:26	1225 2330
	KNKX	33	N 325211 W1170917	430 430	215 215	67.5 352.1	150C 151G	+08+26 02:34:52	306 2024

Starting Configuration:
 2 AIM-9 (SIDEWINDER) [WING TIP]
 4 WING PYLON
 1 CL PYLON
 2 330 GAL TANK [WING]
 1 TFLIR [FUSELAGE]
 1 LDT [FUSELAGE]
 1 330 GAL TANK [CENTERLINE]

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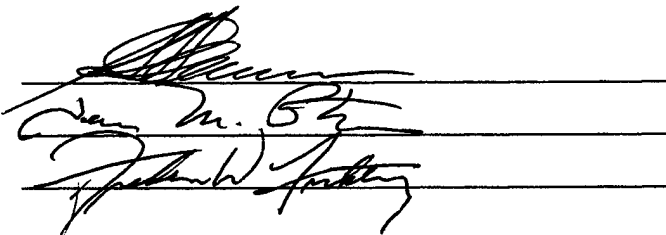
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